

**Completing the Development of Multiple-Choice Quizzes and Practice Exams for the  
Master of Science in Perfusion Students at Milwaukee School of Engineering**

by

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## Abstract

The Milwaukee School of Engineering (MSOE) primarily delivers tests and exams in short-answer format to their Master of Science in Perfusion (MSP) graduate students. This method has been deemed to be an effective way of learning as evidenced by the pass rate of MSOE graduates on the American Board of Cardiovascular Perfusion's (ABCP) examinations. Students, however, are lacking materials to practice for the board examinations and are unable to adequately familiarize themselves with the multiple-choice format found on these exams. Surveys were sent out to students in 2019 and 2021 and it has been found that there is a strong interest in having multiple-choice quizzes and practice exams created as a study tool for these exams. Previously, both Schmidt and Kress developed multiple-choice questions for anatomy, physiology, pathology, pharmacology, and all clinical extracorporeal perfusion courses in the MSP curriculum. The goal of this project was to create multiple-choice questions for the remaining courses, including Pediatric Clinical Perfusion, Design of Experiments, and the Seminar of Medical Ethics, and to create half-length practice exams for additional student practice.

A total of 138 questions were created as part of this project, all of which were derived from the course delivery materials used in the MSOE core curriculum. The questions used for the practice exams were chosen in a randomized manner to avoid bias and repetitiveness. The complete set of questions for the MSOE MSP curriculum is available in Quizlet and are accessible to anyone within the program using the login credentials [MSOEQuizlet@gmail.com](mailto:MSOEQuizlet@gmail.com) as the username and Perfusion1 as the password. Students can now enrich their ABCP board preparation and deepen their understanding with these additional and convenient-to-use study tools.

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## Table of Contents

List of Figures .....	5
List of Tables .....	6
1.0: Introduction .....	7
2.0: Background .....	9
2.1: Benefits of Taking Practice Exams .....	9
2.2: Disadvantages of Multiple-Choice Questions .....	10
2.3: Advantages of Multiple-Choice Questions .....	11
2.4: The American Board of Cardiovascular Perfusion Certification.....	12
2.5: Project Statement .....	13
3.0: Methods .....	15
4.0: Results .....	20
5.0: Discussion .....	24
5.1: Recommendations .....	26
References .....	27
Appendix A: Student Survey Questions and Responses .....	29
Appendix B: Quizlet PedECP – Questions and Answers .....	33
Appendix C: Quizlet DoE – Questions and Answers .....	56
Appendix D: Quizlet ClinECP4 – Questions and Answers .....	66
Appendix E: Quizlet Ancillary Perfusion and Operating Room – Questions and Answers .....	72
References for Appendix E .....	76
Appendix F: Practice Exams – Questions and Answers .....	77
Appendix G: Sample Tests – Questions and Answers .....	145

**List of Figures**

Figure A-1. Survey Questions 1 and 2 .....	29
Figure A-2. Survey Questions 3 and 4 .....	30
Figure A-3. Survey Questions 5 and 6 .....	30
Figure A-4. Student Responses to Survey Questions 1, 2, and 3 .....	31
Figure A-5. Student Responses to Survey Questions 4, 5, and 6 .....	32

**List of Tables**

Table 1. The 11 Major Sections of the ACPB Knowledge Base .....	13
Table 2. Project Development Process .....	15
Table 3. Survey Questions and Response Options .....	16
Table 4. Survey Questions and Responses .....	21
Table 5. List of the Multiple-Choice Quizzes and Tests Created and Uploaded to Quizlet.....	23

## 1.0 Introduction

In the United States, the American Board of Cardiovascular Perfusion (ABCP) is the credentialing organization for perfusionists aiming to become clinical certified perfusionists (CCPs). The ABCP issues certification to qualified candidates, who take and pass their two-part examination: the Perfusion Basic Science Examination (PBSE) and the Clinical Applications in Perfusion Examination (CAPE). Both examinations consist of over 220 multiple-choice questions over a wide range of perfusion-related topics. Most test-takers are recent graduates of perfusion education programs, who need to ensure that they have reasonable knowledge of all topical areas to be best prepared for the exams.

The Milwaukee School of Engineering (MSOE) Master of Science in Perfusion (MSP) program is renowned for administering their course assessments in a short-answer format. While this format may help students understand the material in a deeper way, less and irrelevant material could be presented on these assessments due to instructor's bias. Other than circulating practice exams shared by instructors and paying for ABCP's practice exams, there are not many other venues where students can practice taking relevant exams in a multiple-choice format. Because of these circumstances, two previous student projects have initiated the development of a database of multiple-choice questions to aid students in preparation of the board exams.

The goal of this project is to continue the work of Schmidt [1] and Kress [2] to provide MSOE perfusion students access to additional multiple-choice quizzes extracted from the MSP coursework and other perfusion-specific resources to increase student-preparedness for their board examinations. While Schmidt chose Blackboard to be the platform to contain his quizzes, Kress broadcasted his work on Quizlet, a "more

ergonomic platform with mobile application use.” [2] and this trend will be continued in this thesis. Kress and Schmidt had created a total of 1040 multiple-choice questions (MCQs) varying over 39 different core MSOE curriculum topics. This project will add the questions related to the remaining courses: Pediatric Extra-Corporeal Perfusion, The Design of Experiments, and Seminar of Medical Ethics, to finish creating MCQs for all MSOE curriculum topics. In addition, this project will create four, half-length practice examinations, as another source of supplemental board preparation help. By providing these additional MCQs and examinations, students can utilize this as a tool to become more prepared for their board certification examinations in a convenient and cost-effective way.

## **2.0 Background**

### **2.1 Benefits of Taking Practice Exams**

Taking the board examinations is a stressful event. Other than doing well in an accredited program, there is no real gauge of preparedness to ensure one is ready to take their board exams. This can bring on feelings of self-doubt and a lack of confidence. Practice examinations, however, can be a gauge of preparedness and improve confidence [3]. In a study of 245 medical students, 100 percent of respondents gave feedback that the practice exams were “fantastic” or “good” [3]. This is important because even as busy medical students, taking these practice exams were not a waste of time. These tests had enriched the students in two main ways: it boosted their confidence and it gave them real-time valuable feedback [3].

In the highest level of performers, confidence is a key, mental skill that requires constant nurturing [4]. With a high confidence level, performers are more likely to achieve their goals. But due to confidence’s fragility, low levels can have a negative impact on performance [4]. Practice exams, when made correctly, can boost self-confidence. In a study with 245 medical students, the practice exams were made and reviewed under the direction of a medical educator before being attempted by students [3]. This process resulted in a practice exam that was representative of the information that would be on the graded exam. Students reported that this was beneficial because they were able to know what was expected of them, and how to best improve and prepare for the next exam [3]. A combination of clear expectations and a sense of preparedness can enlighten students as to their progress, ameliorate self-doubt, and overall improve confidence in their ability to perform well on their exam.

Practice exams also offer real-time feedback. With most standardized tests, results typically come in the mail days or weeks after one has taken the test. This delay of feedback has been shown to leave the student unchanged, or not improving from this type of delivery of feedback [5]. A meta-analysis of over 40 feedback-based reports have shown that immediate feedback is more ideal for educational learning and development [5]. The analysis also showed that feedback that is more descriptive as to reason why something is correct is more advantageous than feedback that signals whether something is correct or incorrect [5]. Practice exams can meet this criterion because they are typically not given in a standardized way. Students can pose questions to educators about individual concerns on a question, or an educator can publish thought-out responses as to why an answer is correct. Ultimately, this boost of confidence and feedback provided by practice exams can give students a desire to gauge their learning and to take more practice exams to enhance their state of preparedness [3].

## **2.2: Disadvantages of Multiple-Choice Questions**

Multiple Choice Questions (MCQs) have been widely used as a format for quizzes and examinations [6, 7]. While these questions can be written fairly easy and can cover various topics, MCQs have a number of shortcomings; there's a high chance of guessing the answer, it is difficult to test higher-order thinking, and it is difficult to write flawless questions [6].

In a traditional four-answer MCQ, the probability of guessing an answer correctly is 25%. This percentage greatly increases if distractors are not used correctly, thus reducing the test's reliability [8]. This is problematic because the examinee may be able to guess the correct answer but may not know or fully understand the material posed by the

question [8, 9]. MCQs can ultimately misinform examinees on their level of knowledge for a given subject due to the innate ability to guess.

MCQs lack substantial power to nurture higher-order thinking [6, 10]. These questions are better suited to test factual knowledge, which is lower-order thinking [7]. Having the ability to elaborate and defend one's position makes short-answer or essay formats more apt in assessing higher-order thinking [10].

Flawless MCQs are hard to come by. There is an immense number of interpretations that can be derived from poorly written MCQs, which allows the possibility of an incorrect answer to be justifiable. A situation where this can occur is when absolute true or absolute false wording (never, always, etc.) is incorporated into the questions or answers [6]. Educators may also use phrases, rather than formally posing a question [7]. These types of questions are not typically focused and do not present a clear, and concise question. These flaws, along with writing inappropriate distractors, lead to the "testing of the test-wiseness" of the examinee in lieu of their knowledge and cause unprecedented difficulty [11].

### **2.3: Advantages of Multiple-Choice Questions**

Multiple-choice questions (MCQs) have proven to be beneficial in helping students achieve curricular goals. Educators can measure student success and their achievement of their goals by sampling a wide array of content [11]. Because answering MCQs is quick, educators are allowed to generate a plethora of questions covering a broad domain, as opposed to short-answer questions, which are much more time-consuming to answer [7, 12]. The broad domain of interest also avoids bias that other test formats may experience [8, 9]. As long as the quality of MCQs that educators choose to use are of a high standard,

MCQs can be used as a tool to expose weaknesses in student learning and provide quality feedback [13].

MCQ formatted tests have also been found to serve as an empowering learning tool [14]. If MCQ tests have competitive, and relevant distractors, then these tests have demonstrated the ability to improve retention of both tested and non-tested information over short and long intervals [15]. A study was conducted to test the improved retention rate, and as examinees took initial and intermittent MCQ tests, they were found to score better on a final than those who reviewed their material via recall [15]. At the very least, MCQs can act as an exceptional resource to improve the retention and performance of examinees.

#### **2.4: The American Board of Cardiovascular Perfusion Certification**

To obtain the title of a certified clinical perfusionist (CCP), one must take and pass the certification examination, which is administered by the American Board of Cardiovascular Perfusion (ABCP). The examination is divided into two parts: the Perfusion Basic Science Examination (PBSE), and the Clinical Applications in Perfusion Examination (CAPE). Each of these exams consist of over 220 multiple-choice questions over 11 major categories (Table 1) [15]. Supplemental MCQs can be utilized as a study tool to help student retention and preparedness for this vital examination.

**Table 1. The 11 Major Sections of the ABCP Examination Knowledge Base.**

1. Anatomy & Physiology
2. Pharmacology
3. Pathology
4. Laboratory Analysis
5. Quality Assurance
6. Devices & Equipment
7. Clinical Management
8. Special Patient Groups
9. ECMO/ECLS/Special Procedures and Techniques
10. Catastrophic Events & Device Failure
11. Monitoring

## **2.5: Project Statement**

The graduate students in the MSP program at MSOE do not get to familiarize oneself with the multiple-choice format presented on their board examinations because they are mainly tested in a short-response format. Schmidt and Kress created questions covering all topics within the MSOE MSP curriculum that would be found on the ABCP

board examinations, with the exception of Pediatric Extra-Corporeal Perfusion. There are additional courses in the MSOE MSP curriculum that contain information that is unlikely to be tested on the board exams, but that is aimed at creating well-rounded graduates.

Creating multiple-choice questions for these courses will give students another study tool option to study for finals and to do well in their accredited perfusion program. The goal of this project was to expand the topics over which MCQs were available and to specifically:

1. Create MCQs related to the Pediatric Extracorporeal Perfusion course.
2. Create MCQs related to the courses: Design of Experiments and Seminar of Medical Ethics.
3. Create four half-length practice exams from the MCQ quizzes.
4. Incorporate the addition of approved ABCP sample tests.

### 3.0 Methods

While continuing the work of Schmitt [1] and Kress [2], additional multiple-choice questions and comprehensive practice exams were still needed to complete what they had started. This project achieved completion of the remaining question sets by following the phases detailed in Table 2. The same goal that Schmitt and Kress created was still the focus of this project: to provide easily accessible, non-graded, supplemental quizzes for current and former students to test their knowledge in preparation of the American Board of Cardiovascular Perfusion's (ABCP) examination.

**Table 2. Project Development Process.**

Phase 1: Re-Conduct a Survey of Current Students
Phase 2: Construct MCQs for Remaining Classes in the MSOE MSP Curriculum
Phase 3: Construct Additional MCQs Related to Clinical Perfusion but not Found in the MSOE MSP Curriculum
Phase 4: Generate Half-Length Mock Examinations from Course MCQs and Sample Board Tests
Phase 5: Upload and Deploy MCQs and Mock Examinations to Quizlet

Schmitt had conducted a survey for students who had graduated the MSOE MSP program in 2019 and 2020 [1]. To ensure the value and usefulness of this project, phase

one entailed a survey that was conducted for the current 17 MSOE MSP students, who will graduate in 2021 and 2022. Google Forms was used to design the survey and the link was sent via email. Table 3 outlines the survey's questions and response options.

**Table 3: Survey Questions and Response Options.**

Question	Response
Were you aware of a Quizlet account created by former students that contains supplemental multiple-choice questions (MCQs) created from the MSOE MSP curriculum?	Multiple Choice (Yes, No, or Maybe)
Do you know the account information that allows access to these MCQs?	Multiple Choice (Yes, No, or Maybe)
Which response best describes the likelihood of you using this supplemental tool?	Multiple Choice (I will for sure use it, I might use it, I probably will not use it, I will not use it)
How helpful do you feel mock examinations would be in your preparation for the ABCP board examinations?	Linear Scale [1 (Helpless) to 5 (Very Helpful)]
Which question format do you think would best prepare you for taking your boards?	Multiple Choice (Multiple-choice, Short answer, Other)
Is there any additional information that you would have liked to have seen on this survey? (Optional)	Short Answer

Schmitt and Kress had generated MCQs representing material covered in most of the MSOE MSP curriculum. This project included adding questions from the three main

courses that had not been covered to date (Phase 2). These courses included Pediatric Extra-Corporeal Perfusion, The Design of Experiments, and Seminar of Medical Ethics.

Phase 3 consisted of the creation of additional MCQs outside the scope of the MSOE MSP curriculum, but within the realm of perfusion. These questions can add additional insight and student success on the ABCP board examinations.

Because of the nature of these questions, which is to prepare a student for the ABCP board examinations, the format, style and level of difficulty upheld the standard given by the ABCP practice exam. All questions were given at least four options to choose from, as this gave ample space for strong distractors to adequately test a student's knowledge. This also lessens the likelihood of simply guessing the correct answer.

In preparation of developing these MCQs, various resources were reviewed and studied to enrich the quality and effectiveness of these questions [7, 16, 17, 18, 19]. Avoiding answers like "All of the Above" or "None of the Above" was applied to these questions. Schmitt and Kress had randomized all question answers. This decision was preserved throughout this project to avoid any author bias. All answers were kept relevant to the subject matter that was being tested upon. For example, if a question asked for specifics regarding pediatric kidney function on cardiopulmonary bypass, then answers regarding pediatric lung function were not listed. All questions were reviewed and approved by a current instructor in the MSOE MSP curriculum. Lastly, each created question has an explanation of why the answer is correct and why other possible answers, if appropriate, are incorrect. MCQs from public sample boards will contain explanations if they are already provided. Otherwise, only the answer will be displayed.

All MCQs were first created on a Microsoft Word document, similar to how the MCQs, which were created by Schmitt and Kress, were first made. Microsoft Word is a

popular application found on most computers, which in turn makes accessing and editing these questions convenient. These documents were sent to the appropriate instructors and changes were made based on their feedback and suggestions. After the cycle of editing and reviewing was complete, questions that were satisfactory were ready to be uploaded onto Quizlet (Phase 5).

In Phase 4, mock examinations were created by using the same questions contained in this project and from the work of Schmitt and Kress. Each question was assigned a number based on the order they appeared in each editing document. The order first started with Schmitt's list of questions, then moved to Kress' questions, and lastly moved to the questions created from this project. Questions were then picked by using a random number generator to make certain that various topics were included in each practice examination. Four total examinations consisting of 100 questions each were made. No questions were repeated as each number was kept track of and excluded from the random number generation. Questions from the courses, The Design of Experiments, and Seminar of Medical Ethics, were omitted from the practice exam question pool as they do not pertain to the ABCP board exam criteria.

Sample board tests have been made available to each MSOE MSP student via PDF documents in the Clinical Extra-corporeal Perfusion IV course. These tests are viable options in board preparation because these tests are relatively recent. They range from years 2014, 2015 and 2018. Since students have public access to these questions, these MCQs will be added to their own separate folder to encourage students to get a real board test-taking experience.

Using the instructor email that was created by Kress [2], the MSOE-perfusion account on Quizlet was accessed to deploy the new MCQs and practice examinations.

Folders of each new subject; Pediatric Extra-Corporeal Perfusion, Extra-Corporeal Membrane Oxygenation material, The Design of Experiments, and Seminar of Medical Ethics, were created. Within the individual folder, MCQs were submitted into sets. Questions were entered on the term side, and answers and feedback were presented on the definition side of the flashcard. Practice examinations followed the same format, except no answer or feedback was placed on the definition side of the flashcard. Instead, the specific folder and set was entered on the definition side, so that the student would have a quick way to reference back to the original question and feedback. The last flashcard on each practice exam had a list of answers for students assess what questions they answered correctly or incorrectly. Students will be able to access the finished content by using the student login, which was created by Kress as well [2].

## 4.0 Results

The survey was answered in its entirety by 17 of the 18 current students enrolled in the MSOE MSP program. The responses suggest that over 82% of students would “for sure” use these supplemental questions and quizzes, and 76% of students feel that mock examinations would be very helpful in studying for the ABCP exams. All responses are recorded in Table 4.

**Table 4. Survey Questions and Responses.**

Question	Response		
Were you aware of a Quizlet account created by former students that contains supplemental multiple-choice questions (MCQs) created from the MSOE MSP curriculum?	Yes	10	58.8%
	No	7	41.2%
	Maybe	0	0%
Do you know the account information that allows access to these MCQs?	Yes	5	29.4%
	No	12	70.6%
	Maybe	0	0%
Which response best describes the likelihood of you using this supplemental tool?	For sure use it	14	82.4%
	Might use it	3	17.6%
	Probably will not use it	0	0%
	Will not use it	0	0%
How helpful do you feel mock examinations would be in your preparation for the ABCP board examinations?	Very Helpful (5) (4) (3) (2) Helpless (1)		
Which question format do you think would best prepare you for taking your boards?	Multiple-choice	15	88.2%
	Short Answer	1	5.9%
	Other	1	5.9%
Is there any additional information that you would have liked to have seen on this survey? (Optional)	-None.  -Which question format do you think would best prepare you for taking your boards? – In the same format as the board exams.  -How much can you bench press?		

Table 5 summaries the topics and the number of questions pertaining to that topic for this project, which consisted of 138 MCQs categorized in 19 separate topics. In addition, with Schmitt's and Kress' work, the final project consisted of 1,178 MCQs divided into 90 individual topics. A couple questions were repeated as the content was

repeated in later times throughout the course. Questions were made for these repeated topics as the instructor mentioned the importance of the re-visited topics. All new questions made in this project in Phases 2 and 3 can be found in Appendices B through E.

**Table 5. List of the Multiple-Choice Quizzes and Tests Created and Uploaded to Quizlet.**

Name of Multiple-Choice Quiz	Number of Questions
PedECP – Embryology and Fetal Circulation	16
PedECP – Congenital Heart Defects	12
PedECP – Preoperative Patient Evaluation, Patient Populations, and Monitoring Lines	7
PedECP – Myocardial Protection, and Special Considerations	7
PedECP – Cardiopulmonary Bypass Considerations	8
PedECP – Perioperative Anesthetic Considerations	7
PedECP – Neurological Effects of Cardiopulmonary Bypass, Hypothermic Techniques, and Neuro-Protective Strategies	5
PedECP – Pediatric Extracorporeal Membrane Oxygenation (ECMO), CPS, and ECLS	7
PedECP – Circulatory Assist Devices	5
DoE – Research Concepts, Principles of Measurement, Reliability and Validity, and Descriptive Statistics	7
DoE – Hypothesis Testing, and Diagnostic Tests	7
DoE – Single Sample, Unpaired, and Paired T-Tests	5
DoE – ANOVA	6
DoE – Correlation and Regression Analysis	7
DoE – Non-Parametric Statistics	5
ClinECP4 – Evidence Based Medicine	5
ClinECP4 – Business and Legal Aspects of Perfusion	6
ClinECP4 – Techniques for Exam Preparation	4
Ancillary Perfusion and Operating Room Questions	12
Practice Exam 1	100
Practice Exam 2	100
Practice Exam 3	100
Practice Exam 4	100
Sample Test 1	120
Sample Test 2	120
Sample Test 3	200

## 5.0 Discussion

In the MSOE MSP program, the dominant form of assessment is short answer. This has been an effective method of education, reflected in the near 100% first-time pass rate of graduates who took the ABCP board examinations. Although the pass rate is exemplary, additional MCQs may provide supplemental support in preparing for the ABCP examinations, as these are delivered in a multiple-choice format. Students can familiarize oneself with this format with the practice quizzes and examinations found on the Quizlet page.

It has been made apparent by the MSOE board pass rate that if a student masters the information provided by the curriculum, then they will do relatively well on examination day. The curriculum, however, cannot teach a student everything, as some material will need to be learned by experience and in an operating room setting. For example, a student, who had graduated MSOE MSP program and sat for the ABCP boards in the Fall of 2020, confirmed that the boards contained a question about atrial myxomas, but there was no mention made of this in the MSOE curriculum. While this can be viewed as an oversight, it is more realistic to acknowledge that perfusionists are exposed to a vast amount of knowledge and situations.

While most of the didactic and clinical curriculum was already developed into MCQs, the questions created in this project will complete the coverage from the remaining courses. Clinical topics contain more questions as their usefulness is more prudent in ABCP board preparation. Despite that The Design of Experiments and Seminar of Medical Ethics course material will not be necessarily be found on either the PBSE or CAPE, creating MCQs for these courses was deemed beneficial to promote student

success in the MSOE MSP program. One cannot take the ABCP examination if they do not pass and graduate from an accredited perfusion program.

Schmitt and Kress omitted from creating large, cumulative exams in fear of the tests being redundant. Students, who will take these tests, will have likely seen the questions already since the MCQs will be extracted straight from their quizzes. But now that the Quizlet account has over 1,178 MCQs to choose from, it is less likely that students would recognize a specific answer from a specific answer from the quizzes. This would require a lot of time for a student to familiarize oneself with each individual question and answer. Not to mention that since the longer practice exams will have questions appearing from varying topics in a randomized order, the likelihood of students memorizing the answer is reduced, as opposed to taking a short quiz over an individual topic.

It is important to note that each MCQ, quiz, and test is intended for supplemental learning. While these MCQs come from the MSOE MSP curriculum, official course materials and instructors should be the main sources of information for student learning. Due to Quizlet's accessibility and viability, it would be uncomplicated for an instructor to incorporate this into their course. For access to both student and instructor accounts for the MSOE MSP Quizlet, one can refer to Appendix A of Kress' work [2].

With the costly and limited amount of practice examinations provided to perfusion students, these free and convenient quizzes and tests can be a tool in student preparation. Deeper learning can be acquired by the provided feedback found on the Quizlet exams, which is unlike typical practice examinations provided by the ABCP. Ultimately, the goal of this project was to complete the work done by Schmitt and Kress by finishing MCQ generation of the remaining core curriculum and providing optional practice examinations to students [1, 2].

## **5.1 Recommendations**

In the recent survey given to the MSOE MSP graduating classes of 2021 and 2022, almost 60% of students did not know that a Quizlet page even existed. This could be problematic in the sense that three thesis projects could potentially go to waste. The student Quizlet login information needs to be found on a consistent, program-wide document that new students will see each year. This information can be amended into the red perfusion handbook as this handbook is the guide for the introduction to the program given to first year students.

In addition to the student Quizlet login information, the teacher Quizlet login should be made available to all students upon request. The field of perfusion is relatively new and guidelines for safe and better practices are ever-changing. Students should be allowed to generate new MCQs and add them to the corresponding folders to keep the quizzes and tests in line with current guidelines. Any new MCQ should be reviewed by an active instructor in the MSOE MSP program to verify the quality and correctness of the question.

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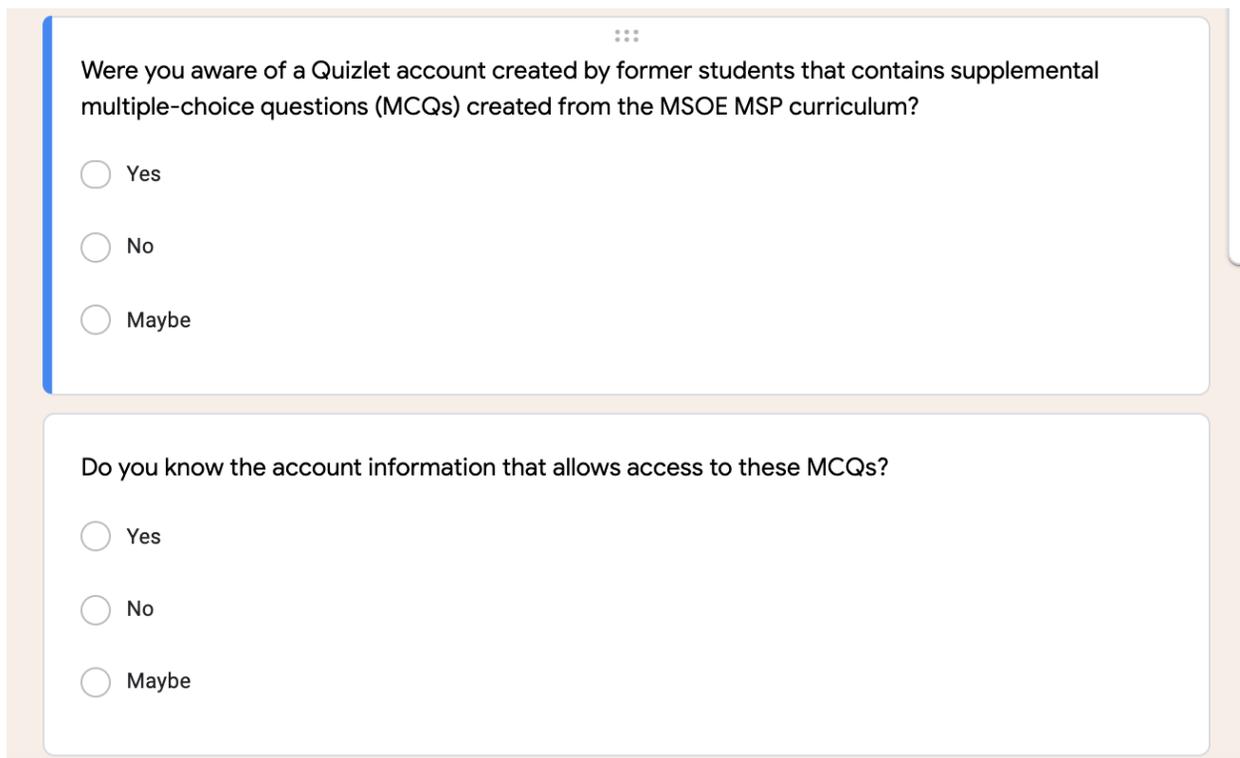
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## Appendix A: Student Survey Questions and Responses

This appendix displays the student survey deployed to the MSOE MSP 2021 and 2022 classes. This survey gauges the interest level of current students having additional supplemental MCQs and practice exams. The survey was created using Google Forms.

### Survey Questions



The image shows a screenshot of a Google Form with two questions. The first question asks if the respondent is aware of a Quizlet account created by former students containing supplemental multiple-choice questions (MCQs) from the MSOE MSP curriculum. The second question asks if the respondent knows the account information that allows access to these MCQs. Both questions have three radio button options: Yes, No, and Maybe.

⋮

Were you aware of a Quizlet account created by former students that contains supplemental multiple-choice questions (MCQs) created from the MSOE MSP curriculum?

Yes

No

Maybe

Do you know the account information that allows access to these MCQs?

Yes

No

Maybe

Figure A-1. Survey Questions 1 and 2.

⋮

Which response best describes the likelihood of you using this supplemental tool?

I will for sure use it

I might use it

I probably will not use it

I will not use it

How helpful do you feel mock examinations would be in your preparation for the ABCP board examinations?

1                      2                      3                      4                      5

Helpless                                                                                                                                    Very Helpful

**Figure A-2. Survey Questions 3 and 4.**

⋮

Which question format do you think would best prepare you for taking your boards?

Multiple-choice

Short answer

Other

Is there any additional information that you would have liked to have seen on this survey? (Optional)

Long answer text  
.....

**Figure A-3. Survey Questions 5 and 6.**

## Survey Responses

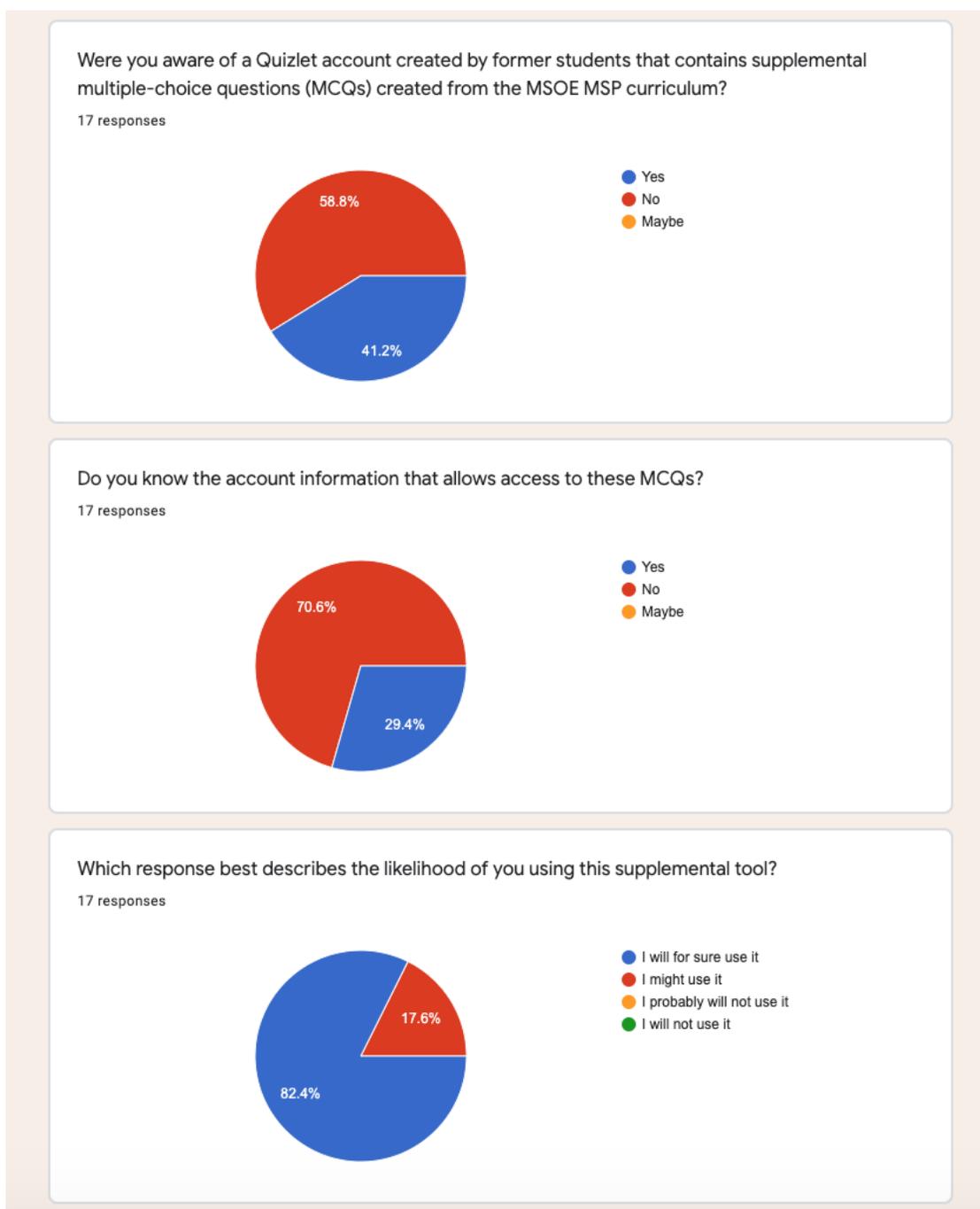


Figure A-4. Student Responses to Survey Questions 1, 2, and 3.

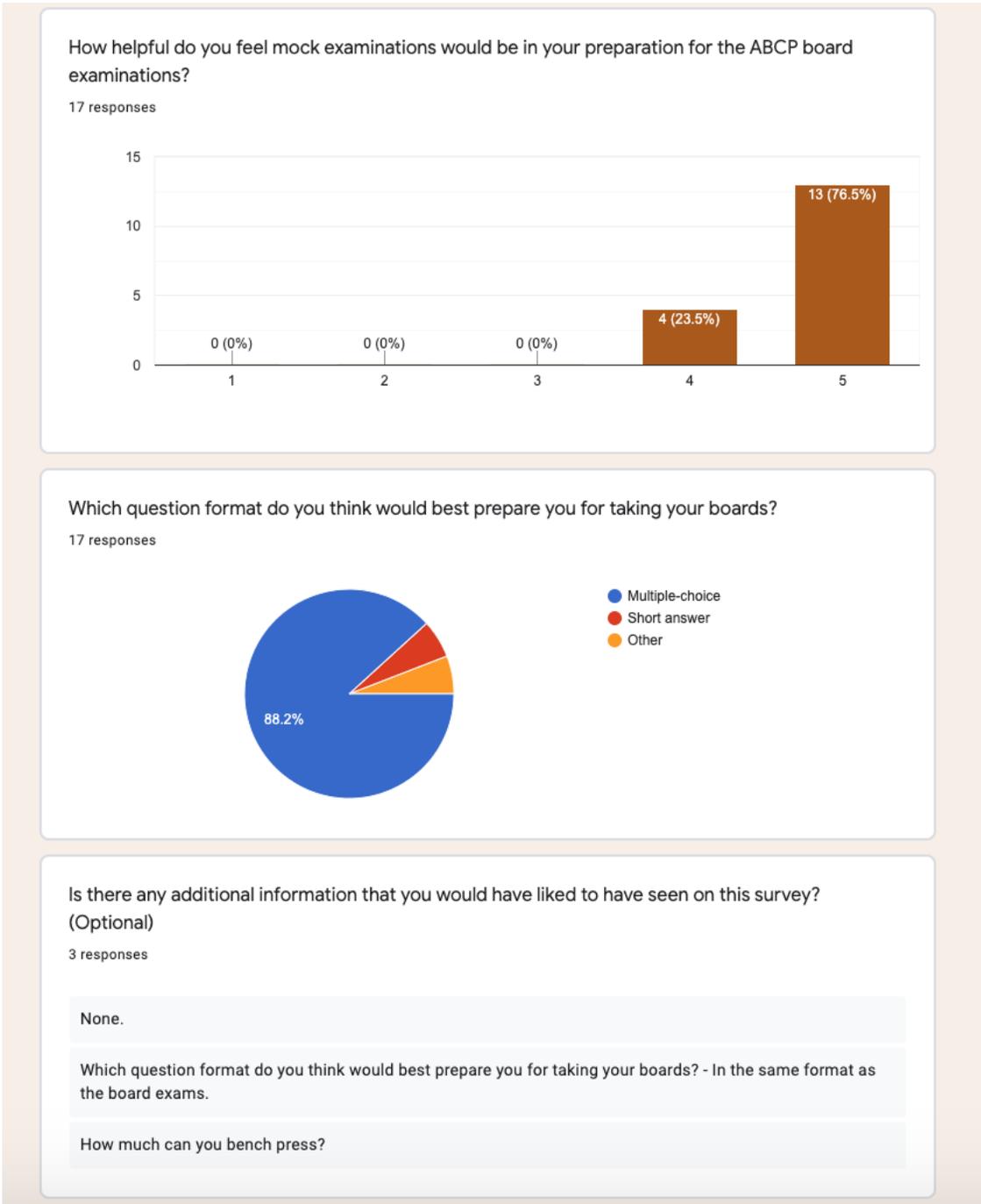


Figure A-5. Student Responses to Survey Questions 4, 5, and 6.

## Appendix B: Quizlet PedECP – Questions and Answers

This appendix features all the multiple-choice questions and answers created for the pediatric clinical perfusion course that were uploaded to Quizlet.

### PEDATRIC CLINICAL PERFUSION

#### EMBRYOLOGY AND FETAL CIRCULATION - 16 QUESTIONS

All these structures arise from the straight heart tube, except for:

- a. Ventricle
- b. Mesoderm
- c. Truncus arteriosus
- d. Bulbus cordis

The correct answer is mesoderm. The straight heart tube creates the atria, ventricles, bulbus cordis and truncus arteriosus. The bulbus cordis contribute mostly to the formation of the ventricles, while the truncus arteriosus becomes the great vessels. The mesoderm is a layer of skin that gives rise to cardiac progenitor cells.

With regards to cardiac looping, which of the following is true?

- a. D-looping is when the LV is positioned leftward, and L-looping is when the LV is positioned rightward
- b. L-looping is when the LV is positioned leftward, and D-looping is when the LV is positioned rightward
- c. D-looping is when the RV is positioned leftward, and L-looping is when the RV is positioned rightward
- d. L-looping is when the RV is positioned leftward, and D-looping is when the RV is positioned rightward

The correct answer is L-looping is when the RV is positioned leftward, and D-looping is when the RV is positioned rightward. Looping occurs due to the different growth rates of the various portions of the heart tube. Normal looping (D-looping) has the sinus venosus positioned posteriorly, the common ventricle moving anteriorly, and the bulbus cordis positioned anteriorly and superiorly. Abnormal looping (L-looping) is still unclear on why this happens.

Which statement is true about the Foramen ovale?

- a. It is formed from the septum primum and septum spurium
- b. This creates a permanent ventricular separation
- c. It closes at birth when the LA pressures are higher than the RA pressures

- d. It closes at birth when the LV pressures are higher than the RV pressures

The correct answer is it closes at birth when the LA pressures are higher than the RA pressures. The foramen ovale is a permanent atrial separation that forms from the septum primum and septum secundum.

Which of the following statement(s) are false about the sinus venosus?

- a. It is the cavity the vena cava drain into during early fetal circulation
- b. The left horn and sinus venosus become the RA
- c. It contributes to the conduction system and development of the SA and AV nodes
- d. The left and right horns are connected to umbilical, vitelline, anterior and common cardinal veins
- e. A and D

The correct answer is the left horn and the sinus venosus become the RA. It is the right horn, not the left horn, and the sinus venosus that become the RA. The smooth portion of the mature RA is derived from the sinus venosus. And it's important to mention that the right anterior cardinal vein and the common cardinal veins form the SVC (those veins are connected to the right and left horns).

The IVC develops from which of the following segments?

- a. Renal segment
- b. Hepatic segment
- c. Post-hepatic segment
- d. Pre-renal segment
- e. Splanchnic segment
- f. Post-renal segment
- g. A, B, C, D
- h. A, B, D, F
- i. C, E, F, D

The correct answer is A, B, D, F. The hepatic segment is the right vitelline vein. The pre-renal segment is the right subcardinal vein. The renal segment is the subcardinal and supra cardinal anastomosis. The post-renal segment is the right supra cardinal vein.

Of the six fetal aortic arches, which two do not develop into major arteries?

- a. 4 and 5
- b. 1 and 3
- c. 2 and 6
- d. 2 and 5

The correct answer is 2 and 5. The first arch develops into the maxillary, and external carotid arteries. The third arch turns into common carotid arteries and internal carotid arteries. The fourth develops into the proximal right subclavian artery, and the transverse

aortic arch. The sixth arch develops into the proximal left and right pulmonary artery and the ductus arteriosus.

Early fetal circulation can be depicted as:

- a. Morphological RA → RV → Truncus Arteriosus → LA → LV → aortic sac → aortic arches
- b. Morphological RA → RV → LA → LV → Truncus Arteriosus → aortic sac → aortic arches
- c. Morphological RA → LA → RV → LV → Truncus Arteriosus → aortic sac → aortic arches
- d. Morphological RA → LA → Truncus Arteriosus → LA → LV → aortic arches → aortic sac

The correct answer is morphological RA → LA → LV → RV → Truncus Arteriosus → Aortic sac → aortic arches. This flow begins around the third week, and once the flow is through the aortic arches and dorsal aorta, then nutrients are delivered to the embryo.

The first route of late fetal circulation:

- a. Begins with the right atrium and ends with the placenta
- b. Begins with the IVC and ends with the umbilical arteries
- c. Begins with the SVC and IVC and ends with the aorta
- d. Begins with the umbilical vein and ends with the placenta

The correct answer is begins with the umbilical vein and ends with the aorta and head vessels. The first route of late fetal circulation is umbilical vein, ductus venosus, IVC, RA, foramen ovale, LA, MV, LV, aortic valve, aorta, head vessels, descending aorta, umbilical arteries, and ends with the placenta.

The second route of late fetal circulation:

- e. Begins with the SVC and ends with the pulmonary artery
- f. Begins with the SVC and ends with the lungs or aorta
- g. Begins with the RA and ends with the lungs or aorta
- h. Begins with the IVC and ends with the pulmonary artery

The correct answer is begins with the SVC and ends with the lungs or aorta. The second route of late fetal circulation follows this route: SVC, RA, tricuspid valve, RV, pulmonary valve, pulmonary artery, lungs and/or aorta.

The placenta is a fetus' largest contributor to what hemodynamic factor?

- a. High SVR
- b. High PVR
- c. Low SVR
- d. Low PVR

The correct answer is low SVR. The placenta acts as a large shunt in the fetus' body. The placenta also is considered the organ of respiration over the lungs, and assists in kidney function and GI function.

The only source of oxygen for the placenta comes from:

- a. The maternal uterine veins
- b. The maternal uterine arteries
- c. The mother's lungs
- d. The umbilical cord

The correct answer is the maternal uterine veins. The fetus does not require a high PO<sub>2</sub> and saturation to develop, unlike its mother. The PO<sub>2</sub> is about 30-35 and is saturated at 70%. This is a hypoxic state relative to the average adult's arterial values, which are a PO<sub>2</sub> of 95 and saturations of 96%.

Which effect does NOT result in the fetus' drop in PVR as they take their first breath?

- a. A fall in pCO<sub>2</sub>
- b. An increase in O<sub>2</sub>
- c. The removal of the placenta
- d. The mechanical effect of the lungs filling with gas

The correct answer is the removal of the placenta. CO<sub>2</sub> is a potent pulmonary constrictor, so as this falls, the fetus experiences a lower PVR. The rise of O<sub>2</sub> has the same effect as a decrease in pCO<sub>2</sub>. Lastly, the replacement of the amniotic fluid in the pulmonary vasculature with gaseous O<sub>2</sub> is the last contributor to the decrease of PVR in a fetus as they take their first breath. The placenta decreases SVR, so the removal of that would increase SVR.

Prostaglandin (PG) levels in a fetus:

- a. Increase after delivery
- b. Decrease after delivery
- c. Stay the same after delivery
- d. Decrease before delivery and then increases after delivery

The answer is decrease after delivery. The placenta is the main source of production of PG, and since that is removed, the levels will decline. PG E series is responsible for keeping patent ductus arteriosus open if needed, but this will typically close within 3 days if PGs are not administered.

Which structure change is anatomically correct?

- a. Ductus arteriosus → Ligamentum venosum
- b. Umbilical vein → Ligamentum teres hepatis

- c. Umbilical arteries (proximal) → medial umbilical ligaments
- d. Ductus venosus → Ligamentum arteriosum

The correct answer is umbilical vein → Ligamentum teres hepatis. The ductus arteriosus changes into the ligamentum arteriosum. The ductus venosus turns into the ligamentum venosum. The proximal umbilical arteries change into the superior vesical arteries, while the distal umbilical arteries turn into the medial umbilical ligaments.

Which difference is NOT true between adults and neonates?

- a. Neonates have less parasympathetic innervation than adults
- b. Neonates have less sympathetic innervation than adults
- c. Neonates rely more on heart rate, rather than stroke volume than adults
- d. Neonates have less compliant ventricles than adults

The correct answer is neonates have less parasympathetic innervation than adults. Neonates actually have a fully developed parasympathetic nervous system. It is the sympathetic system that is more immature than adults. Neonates do rely more on heart rate as the ventricles of neonates have less contractile muscle, which makes cardiac output less dependent on the Frank-Starling mechanism.

Neonates...

- a. Can't have high glucose levels as this leads to intracellular acidosis
- b. And their brains can't survive a long period of severe hypoxia without injury
- c. Have a 50/50 split of free-fatty acid and carbohydrate metabolism
- d. Have neuroprotective benefits of maintaining high glucose levels

The correct answer is Have neuroprotective benefits of maintaining high glucose levels. The other 3 options are only true for adults. Children can tolerate severe hypoxia without brain injury as long as glucose levels are high. Carbohydrate metabolism dominates in neonates as it accounts for 95% of O<sub>2</sub> consumption.

## CONGENITAL HEART DEFECTS – 12 QUESTIONS

Which of the following is NOT a left to right shunt?

- a. Atrial septal defects

- b. Cor Triatriatum
- c. Atrioventricular Canal
- d. Ventricular septal defects

The correct answer is Cor Triatriatum. ASDs, VSDs and atrioventricular canal defects all result in a left to right shunt. Aortopulmonary windows, patent ductus arteriosus, truncus arteriosus, double outlet right ventricles, partial anomalous pulmonary venous returns (PAPVRs), and total anomalous pulmonary venous returns also result in left to right shunts. Cor Triatriatum is classified as a left-sided obstructive anomaly.

Which ASD is defined as the abnormal development of the septum secundum?

- a. Septum secundum
- b. Ostium primum
- c. Sinus venosus
- d. Patent foramen ovale

The correct answer is sinus venosus. Sinus venosus ASDs are commonly associated with PAVRs. Septum secundum ASDs are the abnormal reabsorption of the septum primum or shortening of the septum secundum. Ostium primum ASDs have the abnormality of when the septum primum forms. Patent foramen ovale ASDs are the failure of fusion between the septum secundum to the septum primum.

Which type of VSD is the most common?

- a. I
- b. II
- c. III
- d. IV

The correct answer is II. Type II is a perimembranous VSD that results in 80% of VSDs. Type I is a subarterial VSD and results for 1% of total VSDs. Type III is the inlet VSD and results for 10% of VSDs. Type IV is a muscular VSD and results for 2-7% of all VSDs.

What defect is associated with an atrioventricular canal (AVC)?

- a. Sinus Venosus ASD
- b. Subarterial VSD
- c. Septum secundum ASD
- d. Inlet VSD

The correct answer is inlet VSD. The 3 defects attributing to an AVC are an ostium primum ASD, A-V valve defect (cleft MV), and an inlet VSD. The 3 types of AVCs have varying amounts of each defect.

A PDA is a connection between which two great vessels?

- a. Aorta and SVC
- b. Aorta and pulmonary artery
- c. Pulmonary artery and IVC
- d. Aorta and IVC

The correct answer is aorta and pulmonary artery. This should functionally close 10-15 hours after birth and permanently close 2-3 weeks after. A PDA allows for shunting to occur, and this is dependent on the ratio of SVR:PVR.

Truncus Arteriosus has how many different variations of the defect?

- a. One
- b. Three
- c. Two
- d. Four

The correct answer is four. Type 1 is when the MPA arises from the truncal artery. Type 2 is when the branch PA's arise separately but in close proximity. Type 3 is when the branch PA's arise widely separate from the lateral aspects of the truncal artery. And type 4 is when the branch PA's arise from the distal aorta.

Which of the following is NOT a surgical repair for a double outlet right ventricle (DORV)?

- a. BT-shunt
- b. Glenn
- c. Fontan
- d. Usage of a baffle

The correct answer is BT-shunt. The addition of a BT-shunt is referred to as a palliative repair, where it won't correct the actual defect, but it will be therapeutic to the patient. A baffle is used during an intraventricular repair usually from either the LV to the aorta, or from the LV to the PA. The Glenn and Fontan procedures are also a surgical approach to fixing a DORV.

What extracorporeal technique is MOST likely to be used for a total anomalous pulmonary venous return repair?

- a. LV venting
- b. Z-BUF ultrafiltration
- c. DHCA
- d. ANH

The correct answer is DHCA. DHCA is used to complete a total repair of rerouting the pulmonary venous blood to the LA.

An interrupted aortic arch that has an interruption proximal to the left subclavian is defined as:

- a. Type A
- b. Type B
- c. Type C
- d. Type 4

The correct answer is type B. Type A has an interruption distal to the left subclavian. Type C has an interruption between the innominate and left carotid.

Which of the following is NOT a major characteristic of tetralogy of Fallot?

- a. Overriding aorta
- b. RV hypertrophy
- c. Left ventricular outflow tract obstruction
- d. Ventricular septal defect

The correct answer is left ventricular outflow tract obstruction. All other answers are major characteristics of TOF, in addition to right ventricular outflow tract obstruction.

How is D-Transposition of the great arteries is different than C-transposition?

- a. D-Transposition has great vessels and ventricles transposed, while C-transposition does not
- b. D-Transposition only has only one great vessel and ventricle transposed, while C-transposition has both
- c. D-Transposition has great vessels transposed, while C-transposition has both ventricles and great vessel transposed
- d. D-Transposition has only ventricles transposed, while C-transposition has great vessels transposed

The correct answer is D-transposition has great vessels transposed, while C-transposition has both ventricles and great vessels transposed. In D-transposition, the aorta arises from the RV anteriorly to the MPA, which arises from the LV. In C-transposition, both the

ventricles and great vessels are transposed. A common symptom of this is RV failure because it is not meant to pump systemically to the body.

Which of the following is NOT a procedure to fix hypoplastic left heart syndrome?

- a. Norwood
- b. Bidirectional Glenn
- c. Fontan
- d. Ebstein

The correct answer is Ebstein. Ebstein's anomaly is a downward placement of the septal and posterior leaflets of the TV into the RV wall. The Norwood, Bidirectional Glenn, and the Fontan are used to completely restructure the heart to maintain its functionality. These surgical procedures are typically completed over the first few years of life.

### PREOPERATIVE PATIENT EVALUATIONS, PATIENT POPULATIONS, AND MONITORING LINES – 7 QUESTIONS

Which of these diagnostic tests would provide patient information such as SVR, PVR, and pressure gradients within the heart?

- a. EKG
- b. Echocardiography
- c. MRI
- d. Cardiac catheterization

The correct answer is cardiac catheterization. Cardiac catheterization also can provide information about shunts and oxygen saturations within the heart. EKG is a test that shows electrical signals within the heart and is non-invasive. Echocardiography can be performed perioperatively either transesophageally or trans-thoracically. MRIs evaluate lesions that are more difficult to assess via echocardiography, such as coarctation of the aorta, branch pulmonary arterial stenosis, vascular rings, etc.

With neonates, the main goal of palliative procedures is to control \_\_\_\_\_ blood flow to allow for growth but without excessive blood flow to the \_\_\_\_\_ circulation and impaired \_\_\_\_\_ perfusion and volume overload to the \_\_\_\_\_ ventricle.

- a. Pulmonary, pulmonary, systemic, systemic
- b. Pulmonary, systemic, systemic, pulmonary
- c. Systemic, systemic, pulmonary, pulmonary
- d. Systemic, pulmonary, pulmonary, systemic

The correct answer is pulmonary, pulmonary, systemic, systemic. Palliative procedures were historically done more often to allow patients to grow bigger before major cardiac surgery. Now, complete repairs are a major focus to limit consequences such as volume overload and excessive pressures. A good indicator of balanced Qp:Qs is an  $S_aO_2$  of 80-85%. This means the Qp:Qs ratio is approximately 1:1. Examples of palliative procedures that would be used in a pediatric setting would be pulmonary banding, and modified Blalock-Taussig (BT) shunts.

Which cardiopulmonary bypass consideration is NOT a major concern when it comes to premature infant and very low-birth weight neonates?

- a. Pulmonary function
- b. Hematologic composition
- c. Necrotizing enterocolitis
- d. Intraventricular hemorrhage

The correct answer is hematologic composition. Pulmonary function is a concern due to this population group being disposed to obstructive, hypoxia, or ventilation difficulties. Better outcomes are seen when excessive pulmonary flows are corrected right away. Necrotizing enterocolitis is often seen in these patients with congenital heart disease. Improving perfusion and oxygen delivery to the gut is a management strategy to control this consideration. And due to the cerebral immaturity and hemodynamic disturbances of premature infants, intraventricular hemorrhage is a condition that needs to be assessed and diagnosed preoperatively.

Which of the following congenital heart defects is a acyanotic lesion?

- a. TOF
- b. Single ventricular anatomy
- c. Coarctation of the aorta
- d. D-transposition of the great arteries

The correct answer is coarctation of the aorta. Coarctations of the aorta, VSDs, ASDs, aortic stenosis, etc. are acyanotic lesions. These patients and their oxygen saturations are affected by usual parameters, such as cardiac output, hemoglobin, oxygen consumption, etc. TOF, single ventricular anatomy, and D-transposition of the great arteries are cyanotic lesions. These patients and their oxygen saturation needs are met by the ratio of pulmonary to systemic (Qp:Qs) blood flow.

Eisenmenger Syndrome will cause hypertension in which of the following vessels?

- a. Hepatic portal vein
- b. Capillaries in the nephron

- c. Pulmonary veins
- d. Pulmonary arteries

The correct answer is pulmonary arteries. Eisenmenger syndrome is a fixed, irreversible pulmonary hypertension from unrepaired or incompletely repaired intracardiac lesions (VSDs, AV canal). This leads to excessive muscularization of the pulmonary vasculature and causes right to left shunting. This can be managed by taking oral medications for pulmonary hypertension.

Which venous site is the most common site for the CVP line?

- a. Right Subclavian vein
- b. Right external jugular vein
- c. Left internal jugular vein
- d. Right internal jugular vein

The correct answer is the right internal jugular vein. Other possible sites are the subclavian vein, external jugular vein and the femoral vein. A CVP line has large and small port. The larger port is used to monitor CVP and give drug injections. The smaller port is used for vasoactive infusion.

Which arterial monitoring site would you choose for a neonate that is five days old?

- a. Radial artery
- b. Umbilical artery
- c. Femoral artery
- d. Axillary artery

The correct answer is the umbilical artery. This site is accessible within the first 7-10 days of life and is the preferred site of choice for surgery. The radial artery is preferred if the umbilical artery is not a viable option. Be sure to avoid placing this line on the same side as a shunt. Femoral artery can be used if radial access is not available. Be sure to verify distal perfusion to the patient's leg. And lastly, the axillary artery can be used but has high incidence of limb ischemia.

## MYOCARDIAL PROTECTION, AND SPECIAL CONSIDERATIONS – 7 QUESTIONS

What factor will determine the ability or lack of ability for a heart to withstand periods of ischemia and injury?

- a. Level of maturity
- b. Rhythm of the heart
- c. Vascularization of the heart
- d. Temperature of the heart

The correct answer is the level of maturity. The neonatal myocardium is more resistant to ischemia and reperfusion injury than the mature, adult heart. The point of transition is thought to be around the first year of life where the neonatal heart becomes more susceptible to injury. It's important to note that this resistance to ischemia and reperfusion injury is not present in cyanotic or acute/chronic heart failure patients.

Which of the following is NOT an obstacle to overcome when considering cardioplegia delivery to a neonatal patient?

- a. Immaturity
- b. LV function
- c. Cyanosis
- d. Hypertrophic state of the RV

The correct answer is LV function. LV function is not a concern since the LV will be arrested by the cardioplegia solution. Immaturity is an obstacle due to the smaller percentage of contractile proteins, fewer mitochondria and lower oxidative capacity. For a patient with cyanosis, there is a decreased threshold for anaerobic metabolism and less myocardial reserve during stress. PO<sub>2</sub> levels should be kept in the lower range during initiation of bypass and cross clamp removal. And with the hypertrophic state of the RV, if the RV is very hypertrophic, then there's decreased subendocardial flow and lower concentrations of high-energy phosphates.

Which substrate does the pediatric heart use as a main source for energy production?

- a. Fatty acid chains
- b. Amino acids
- c. Nucleic acids
- d. Glucose

The correct answer is glucose. The adult heart has up to 90% of its ATP production come from long fatty acid chains. This change in energy source has not occurred in neonates, as they use glucose or glycogen stores as the main source of energy production. This allows the neonatal heart to have a greater ability to use anaerobic metabolism, which can partially explain its prolonged tolerance to ischemia.

The pediatric heart is more sensitive to extracellular \_\_\_\_\_ levels than the adult heart.

- a. Sodium

- b. Magnesium
- c. Potassium
- d. Calcium

The correct answer is calcium. A possible explanation to this is due to the underdeveloped sarcoplasmic reticulum, which allows for a decrease in calcium storage capacity. Also, the neonate heart is a reduced activity of the sarcoplasmic calcium adenosine triphosphatase. This decreases the ability to release calcium when stimulated. Due to the sensitivity of calcium, it is advised that calcium should not be added to cardioplegia solutions in pediatric practices.

Which enzyme is responsible for the pediatric heart being more tolerant to ischemia?

- a. 5' Nucleotidase
- b. Glutathione reductase
- c. Creatine Kinase
- d. Superoxide dismutase

The correct answer is 5' Nucleotidase. This increases the conversion of adenosine monophosphate (AMP) to adenosine. AMP can't pass through the plasma membrane, but adenosine can, and is potentially lost. This enzyme system is immature in a pediatric heart, so there's less production of adenosine. This leads to an increased enzyme pool, which is important in post-ischemic recovery. Glutathione reductase and superoxide dismutase are important in reducing free radicals. The reduction of these enzyme systems make the pediatric heart more susceptible to free radical injury.

Custodiol is a popular cardioplegic solution used in pediatric heart surgery. What type of arrest does Custodiol activate within the myocardial cells?

- a. Depolarization
- b. Modified depolarization
- c. Hyperpolarization
- d. Modified hyperpolarization

The correct answer is hyperpolarization arrest. This arrest keeps the myocardial cells below or near resting membrane potential. Adding a K-ATP channel agent can reduce sarcolemmal and sarcoplasmic CaATP-ase, and Na-K-ATP-ase activity. This can reduce O<sub>2</sub> consumption ever further. Some contents within Custodiol are histidine, tryptophan, ketoglutarate, and mannitol.

What cardioplegia protocol would most fit a pediatric case?

- a. Frequent, long lasting doses with cold induction
- b. A single, cold dose

- c. Frequent, intermittent doses with warm induction
- d. Intermittent half doses with cold induction and a “cold” shot.

The answer is frequent, intermittent doses with warm induction. While there is no set protocol on how cardioplegia should be delivered, practices are moving away from the single dosing, and gravitating towards intermittent doses with warm induction, hot shots and giving substrate enhancements.

### CARDIOPULMONARY BYPASS CONSIDERATIONS – 8 QUESTIONS

What difference between the adult heart and the pediatric heart is FALSE?

- a. The pediatric heart is much larger than the adult heart, proportionally
- b. The pediatric brain receives 10-15% less CO than adults
- c. Pediatric patients often have a much higher metabolic rate
- d. Cannulation can/may be more difficult in the pediatric patient

The correct answer is the pediatric brain receives 10-15% less CO than adults. The reverse is true. Pediatric brains receive about 34% of cardiac output, while the adult brain receives 15-20%.

For a patient, who is 3 years old, what number cardiac index number times their BSA would you suggest maintaining given you have the means to do so?

- a. 3.2 index
- b. 2.5 index
- c. 2.8 index
- d. 2.4 index

The correct answer is 2.8. Newborns to ages 2 typically need higher flows, which are around a 3-3.2 index\*their BSA. Ages 2-4 typically require a 2.8 index\*their BSA. 4-6 year olds need a 2.6 index\*their BSA. 6-10 year olds need 2.5 indexes\*their BSA and 10+ need a 2.4 index\*their BSA.

For a patient weighing 38kg, how thick of tubing would you want for your arterial line and venous line?

- a. 3/16”, 3/16”
- b. 1/4”, 3/8”
- c. 3/8”, 3/8”

- d.  $\frac{1}{2}$ ",  $\frac{1}{4}$ "

The correct answer is  $\frac{1}{4}$ ",  $\frac{3}{8}$ ". A good reference is that patients less than 4kg want a  $\frac{3}{16}$ " arterial line and  $\frac{3}{16}$ " venous line. 4-10kg want a  $\frac{3}{16}$ " arterial line and a  $\frac{1}{4}$ " venous line. 10-20kg want a  $\frac{1}{4}$ " arterial and  $\frac{3}{8}$ " venous. 20-40 want a  $\frac{1}{4}$ " arterial and  $\frac{3}{8}$ " venous. 40-60 want a  $\frac{3}{8}$ " arterial and a  $\frac{3}{8}$ " venous. >60kg want a  $\frac{3}{8}$ " arterial and a  $\frac{1}{2}$ " venous.

How much blood would you need in your prime for a patient weighing 50kg?

- a. 83 mL
- b. 76 mL
- c. 85 mL
- d. 70 mL

The correct answer is 70 mL. Again as a reference, newborns (15-30 min old) need about 76 mL. Newborns (24 hours old) need 83 mL. 5-10kg patients need 85 mL. 11-20kg patients need 80 mL. 21-45kg patients need 75 mL and greater than 45kg need 70 mL.

Which of the following reasons best explain why neonates are at a greater risk of bleeding?

- a. Immature clotting system
- b. Lower levels of ATIII
- c. Reduced platelet activity
- d. All the above

The correct answer is all the above. The development of the coagulation system is incomplete until about 6 months of age, especially ATIII. This leads to continual thrombin generation and a generally consumptive state during CPB.

Which of these benefits is NOT a major reason to use MUF?

- a. Removal of potassium
- b. Removal of inflammatory mediators
- c. Increasing hematocrit
- d. Improving ventricular functional recovery

The correct answer is the removal of potassium. This is a major benefit of using zero-balance ultrafiltration. Modified ultrafiltration, post-operatively, can also improve pulmonary compliance. Typically this is ran at a flow of less than 20 mL/kg/min, as this may cause cerebral steal. So watch your cerebral saturations.

Your surgeon successfully weans you off of bypass, and you, being the great student you are, observe that the PVR is high. After attempts to mechanically resolve this with vigorous hyperventilation were unsuccessful, your anesthesiologist blanks on a drug to administer to this patient. Which pharmacological agent would best help the patient?

- a. Prazosin
- b. Carvedilol
- c. Nitric oxide
- d. Dopamine

The correct answer is nitric oxide. Alpha stimulation will increase PVR and beta stimulation decreases PVR. Nitric oxide is a selective pulmonary vasodilator, so this will be the best option without other severe side effects. Other possible pharmacological agents that could be used are sodium nitroprusside, milrinone, PGE<sub>1</sub>, etc.

What post-bypass complication may commonly occur in neonates?

- a. Decreased stroke volume
- b. Hyperglycemia
- c. Excessive clotting
- d. Hyperkalemia

The correct answer is hyperkalemia. This typically occurs because of the cardioplegia solution. If cardiac output is decreased, then the hyperkalemia needs to be treated as renal elimination may be compromised. Stroke volume is relatively fixed in neonates, so CO is HR dependent. Hyperglycemia is not a post-bypass complication in neonates. And neonates are known to excessive bleed, not clot.

### PERIOPERATIVE ANESTHETIC CONSIDERATIONS – 7 QUESTIONS

Which of the four lesions has a management strategy to avoid being volume overloaded?

- a. Obstructive lesions
- b. Shunt lesions
- c. Mixing lesions
- d. Regurgitant lesions

The correct answer is regurgitant lesions. The amount of regurgitation is dependent upon preload, afterload and heart rate. Keeping the patient dry can reduce the amount of regurgitation.

What site is not a usable site for a temperature probe?

- a. Esophageal
- b. Rectal
- c. Femoral
- d. Tympanic

The correct answer is femoral. Common sites are esophageal, nasopharyngeal, rectal, tympanic, blood and bladder.

Which of the following is not an inotrope?

- a. Dopamine
- b. Isoproterenol
- c. Milrinone
- d. Epinephrine

The correct answer is isoproterenol. Isoproterenol is a nonselective beta-adrenergic agonist (chronotrope), while all the other 3 options are all inotropes. Other inotropes are dobutamine, calcium, amrinone, and digoxin.

Which receptor does vasopressin act on for the vasoconstricting effect?

- a. Alpha 1
- b. V1
- c. V2
- d. Beta 1

The correct answer is V1. Vasopressin also activates V2, but that is for the antidiuretic effect. Vasopressin is not an alpha 1 or beta 1 agonist.

Which of the following inhalational anesthetics is NOT able to be used during CPB?

- a. Isoflurane
- b. Nitrous oxide
- c. Sevoflurane
- d. Desflurane

The correct answer is nitrous oxide. Isoflurane, sevoflurane and desflurane are able to be used for induction, maintenance and CPB. Nitrous oxide can be used adjunct to a volatile agent during induction and maintenance.

What would be a reason to use Ketamine as an anesthetic?

- a. To act as a direct myocardial depressant
- b. To increase MAP, CVP and SVR
- c. To increase cerebral oxygen consumption
- d. To avoid effecting Qp:Qs blood flow

The correct answer is to avoid effecting Qp:Qs blood flow. Disadvantages to ketamine are that it is a myocardial depressant, it increases MAP, CVP and SVR, and it increases cerebral oxygen consumption. It can also increase intracranial pressure and increase CBF. Although there are a lot of hemodynamic changes, these can be predictable changes at certain doses.

Which neuromuscular blocking agent is a depolarizing agent?

- a. Pancuronium
- b. Succinylcholine
- c. Vecuronium
- d. Rocuronium

The correct answer is succinylcholine. This is rarely used in cardiac surgery due to the association with malignant hyperthermia, hyperkalemic cardiac arrest and bradycardia. Pancuronium is used frequently due to its preservation of HR. Vecuronium has no cardiovascular effects on children. Rocuronium has minimal cardiovascular effects, but it can be painful during injection.

### NEUROLOGICAL EFFECTS OF CPB, HYPOTHERMIC TECHNIQUES, AND NEURO-PROTECTIVE STRATGIES – 5 QUESTIONS

A non-modifiable factor that would affect a child's neurological development would be:

- a. Acidosis
- b. Hypotension
- c. Socioeconomical factors
- d. History of cardiac arrest

The correct answer is socioeconomical factors. A non-modifiable factor is something that cannot be changed. Other examples of this would be genetic syndromes, gestational age, birth weight, and gender. Acidosis, hypotension and cardiac arrest are examples of modifiable factors that are changed pre/peri/postoperatively.

Which buffering system has the highest buffering capabilities at a hypothermic temperature?

- a. Bicarbonate buffering system
- b. The amino acid, Histidine
- c. Phosphate buffering system
- d. Ammonium buffering system

The correct answer is the amino acid, histidine. The amino acid, histidine, has an imidazole ring that is very effective in hypothermic conditions. This is the main reason why pH-stat is used during hypothermic conditions.

How long should a surgeon allow a period of no flow during DHCA?

- a. Less than 15 minutes
- b. No more than 40 minutes
- c. 25 minutes
- d. 30 minutes

The correct answer is no more than 40 minutes. Each surgeon is different and will usually request you warn them in smaller increments of time. Anything greater than 40 minutes is associated with injury.

Low flow CPB is most similar to what other perfusion technique?

- a. SCP
- b. RCP
- c. ACP
- d. Isolated limb perfusion

The correct answer is SCP. Low flow CPB and selective cerebral perfusion are similar in that they have the same cannulation sites. These techniques are associated with preservation of cerebral energy stores, improved cerebral reperfusion, improved histologic outcomes and improved neurologic outcome when compared to DHCA.

As a patient is undergoing DHCA, at what hemoglobin range would a patient yield better outcomes when being hemodiluted?

- a. 22-24%
- b. 18-20%
- c. 14-17%
- d. 25-30%

The correct answer is 25-30%. In the past, hemodilution is used to offset the increased viscosity. The patient was brought to 20% and it was previously thought 14-17% is when damage would occur. Recent studies now suggest that keeping a patient around 25-30% hematocrit is better for patient outcomes.

### PEDIATRIC EXTRACORPOREAL MEMBRANE OXYGENATION (ECMO), CPS AND ECLS – 7 QUESTIONS

Of these treatment options, which of these would be initiated LAST when treating neonatal respiratory failure?

- a. Surfactant replacement
- b. High frequency ventilation
- c. ECLS
- d. Intratracheal pulmonary ventilation

The correct answer is ECLS. ECLS is a last resort therapy as its effects are much more drastic than more conventional therapies. The other options, as well as inhaled nitric oxide and, synchronous mechanical ventilation, are considered conventional therapies.

What criteria would exclude a pediatric patient to be eligible for ECLS?

- a. Less than 10 days of mechanical ventilation
- b. Gestational age >34 weeks
- c. Evidence of severe refractory respiratory failure
- d. An intracranial hemorrhage of a grade I or II

The correct answer is an intracranial hemorrhage of a grade I or II. These can be confirmed via CT or ultrasound and is a big exclusion criteria for ECLS. In addition to this, any profound neurologic impairment is also an exclusion criteria.

Which of the following is an advantage of using neonatal VA ECMO?

- a. Emboli will go to the lungs rather than the brain
- b. Provides the ability to support systemic perfusion in lung/cardiac failure
- c. Preserve Pulsatility with adequate cardiac function
- d. No need to enter or ligate a carotid artery

The correct answer is provides the ability to support systemic perfusion in lung/cardiac failure. Other advantages of VA ECMO are maximization of perfusion pressure to end

organs and to provide full cardiopulmonary support allowing rest to the pulmonary and cardiac systems. The other 3 options are all advantages of using VV ECMO.

Which of the following is NOT a VA ECMO cannulation site?

- a. Cervical
- b. Sternal
- c. Femoral
- d. Right IJ

The correct answer is Right IJ. Cervical, sternal or femoral can all be used for drainage, infusion or combination sites. The right IJ is a common VV ECMO infusion cannulation site where they will feed the cannula down the RIJ and into the SVC. Double lumen cannulas, like an Avalon, will also be fed down the RIJ.

What percent of cardiac output should a flow rate be when a patient is on VV ECMO?

- a. 30-80%
- b. 85-90%
- c. 30-90%
- d. 20%

The correct answer is 30-90%. Flow rates will vary from patient to patient as their degree of sickness and needs vary. VA ECMO typically require flow rates of 30-80% of CO.

Unlike in adults, what major complication that is more frequently posed when considering cannulation sites for a pediatric patient?

- a. If the patient's chest is open
- b. The number of times the patient has been cannulated
- c. The patient's anatomy
- d. The way in which the patient is being monitored

The correct answer is the patient's anatomy. Pediatric patients can have an unique anatomy, such as TGA, Glenn, Fontan, etc. The other considerations are also those posed with adults. If the patient's chest is open, then central cannulation should be considered. Tissue becomes fragile with multiple cannulations, so avoiding those vessels may have to be an option. And pressure lines may also limit cannulation sites.

Which ACT value is most appropriate for a pediatric patient on ECMO?

- a. 150
- b. 480

- c. 300
- d. 190

The correct answer is 190. ACT values should range from 180-200 and should be checked every 30-60 minutes for the first 4 hours. This value can be achieved by a heparin drip at a rate of 20-50 units/kg/hour. Be sure to watch the patient's ACT closely when infusing blood products as the ACT may drop.

### CIRCULATORY ASSIST DEVICES – 5 QUESTIONS

Which of the following is an advantage of ECMO, and not one of VADs?

- a. Less need for anticoagulation
- b. Greater mobility for patients
- c. Biventricular support
- d. Lower risk of infection

The correct answer is biventricular support. Typically a RVAD or a LVAD will be inserted, but not usually a BiVAD. BiVADs are rare because of the LVADs ability to adequately unload the ventricle. ECMO gives full systemic circulation, so it will provide relief to the ventricles. The remaining options are all advantages of VADs.

Which of the following is a disadvantage of VADs, and not one of ECMO?

- a. Need a dedicated team
- b. ICU monitoring
- c. More bleeding
- d. Can't be used with respiratory failure

The correct answer is can't be used with respiratory failure. VADs do not supply any support to the respiratory system. So if respiratory failure is an issue, then ECMO would be the preferred method of treatment.

A patient with congenital tetralogy of Fallot with an absent PV is experiencing respiratory failure. Is respiratory failure an indication of obtaining mechanical support? If it is, then what device would likely be used?

- a. Yes; RVAD
- b. Yes; LVAD
- c. Yes; ECMO
- d. No

The correct answer is Yes;ECMO. Preoperative stabilization is an indication for mechanical support and respiratory failure falls under this category. A contraindication of using VADs is respiratory failure. These devices do not give any respiratory support. ECMO, on the other hand, does.

The heartmate III is a long-term mechanical assist device. It follows a different principle of flow than other devices, such as the Berlin Heart or the Heartmate II. What type of pump does the Heartmate III use to obtain flow to the patient?

- a. Pulsatile
- b. Centrifugal
- c. Roller
- d. Axial

The correct answer is centrifugal. The Heartmate III and the Heartware VADs use centrifugal pumps to flow to the patient. The Berlin Heart uses pulsatile flow, and the Impella and Heartmate II use axial flow.

VADs are preload \_\_\_\_\_ and afterload \_\_\_\_\_.

- a. Dependent, dependent
- b. Independent, dependent
- c. Independent, independent
- d. Dependent, independent

The correct answer is dependent, dependent.

## Appendix C: Quizlet DoE – Questions and Answers

This appendix features all the multiple-choice questions and answers created for the Design of Experiments course that were uploaded to Quizlet.

### Design of Experiments

#### RESEARCH CONCEPTS, PRINCIPLES OF MEASUREMENT, RELIABILITY AND VALIDITY, AND DESCRIPTIVE STATISTICS – 7 QUESTIONS

Which of the following is NOT a descriptor associated with a dependent variable?

- a. Measured
- b. Controlled
- c. Valid
- d. Reliable

The correct answer is controlled. Dependent variables are measured, observed, valid and reliable. This is typically on the Y-axis. Independent variables are controlled, and manipulated. These are found on the X-axis.

Non-invasive measures of blood pressure has been used to predict direct measures of blood pressure for a long time. Typically when this test is given twice, you get answers that are close to the true pressure, but scattered in values. Which reason best explains whether this test is reliable or valid?

- a. It is reliable because this test is consistent and free from error
- b. It is valid because this measurement is relatively free from error
- c. It is reliable because these measurements are reproducible
- d. It is valid because non-invasive measurements can be used to predict direct blood pressure measures

The correct answer is it is valid because non-invasive measurements can be used to predict direct blood pressure measures. Think of the target and shooting arrows. It's important to note that a valid test, like the example above, is also reliable. But a reliable test may not be valid.

Which of the following is an example of an ordinal measurement scale?

- a. Distance
- b. IQ

- c. Pain scale
- d. Gender

The correct answer is pain scale. Ordinal measurement scales measure indicate rank order only, and have no meaning. Distance is a ratio measurement, which is represented with equal intervals and measured from a true zero. IQ is an interval measurement, which is not relative to a true zero, but has an equal interval between numbers. Gender is an example of a nominal measurement scale, which have numbers or letters used only as labels.

Which test is an example of a parametric test?

- a. ANOVA
- b. Percentiles
- c. U-test
- d. Friedman ANOVA

The correct answer is ANOVA. T-test, ANOVA, correlation and regression tests are all parametric, or deals with ratio or interval data. Percentiles fall into a category of descriptive statistics that describe a single sample or population. Friedman ANOVA is an example of a non-parametric test, which deals with ordinal or nominal data.

What statement best defines a P-value?

- a. The area under a curve to the left of the calculated test statistic
- b. The probability of correctly claiming a significant difference when there isn't one
- c. The probability of incorrectly claiming a significant difference when there isn't one
- d. The point at which the curve hits the X-axis

The correct answer is the probability of incorrectly claiming a significant difference when there isn't one. It is also the area under a bell curve to the left of the calculated test statistic.

In a negatively skewed bell curve graph reading from left to right, what order would you find the mean, median and mode?

- a. Mode, median, mean
- b. Median, mode, mean
- c. Mean, mode, median
- d. Mean, median, mode

The correct answer is mean, median, mode. The reverse is true for a right skewed graph, where the order becomes mode, median, mean.

Which variable best represents the degrees of freedom in a single-sample t-test?

- a. X-1
- b. P-1
- c. S-1
- d. N-1

The correct answer is N-1. The sample size is represented with the letter N in statistics. The degrees of freedom represent the number of values in the final calculation of a statistic that are free to vary, or that are independent to move.

### HYPOTHESIS TESTING, AND DIAGNOSTIC TESTS – 7 QUESTIONS

The null hypothesis is a hypothesis being tested for the purpose of a possible rejection and is denoted by  $H_0$ . What symbol would most likely be found in a written null hypothesis?

- a.  $<$
- b.  $>$
- c.  $\neq$
- d.  $=$

The correct answer is  $=$ . The null hypothesis always contains some symbol of equality. Other symbols may be  $\geq$ , or  $\leq$ . The alternate hypothesis will always contain an inequality when written out.

What verbiage is used when making conclusions about a null hypothesis?

- a. Accept or fail to accept
- b. Reject or fail to reject
- c. Reject or fail to accept
- d. Accept or fail to reject

The correct answer is reject or fail to reject. We never say we “accept” the null hypothesis. We cannot accept the null hypothesis especially when type 1 error has only been addressed. Type 2 error needs to be addressed, but even then, the verbiage is not that we would accept the null. It would be that we would have failed to reject it.

What type of error is a P-value associated with?

- a. Type I
- b. Type II

The correct answer is type I. The P-value can be thought of as the probability of making a type 1 error, or having a false positive. Type II is a false negative and is relevant when failing to reject a hypothesis.

What condition needs to be met to allow alpha and beta to both decrease?

- a. N is variable
- b. N is increasing
- c. N is zero
- d. N is one

The correct answer is N is increasing. Alpha, beta and N are all related. Typically, alpha and N are chosen to determine beta. To decrease alpha and beta, you need to increase N.

In what scenario would a z-statistic be correctly chosen as a test statistic?

- a. When the risk of committing a type 1 error is high
- b. When the risk of committing a type 2 error is high
- c. When the sample size is no greater than 15
- d. When the sample size is larger than 30

The correct answer is when the sample size is larger than 30.

An isolated person has trapped themselves in their bunker during the entire time of COVID. They wore a bubble suit to and from the bunker and to the doctor's office to be tested for COVID. This person receives their test results in the mail, and has tested positive. The patient does not believe the results of the test. Which aspect of the test is in question?

- a. Its sensitivity
- b. Its specificity

The correct answer is its sensitivity. Sensitivity can be defined as the probability of a positive test given that the person has a disease. If the sensitivity of the test is good, then the ratio of true positives to false positives will be low. While sensitivity is a better answer than specificity, the real concern here is predictive value positive. Sensitivity does not take the occurrence of false positives into account.

What definition best defines a predictive negative test value (assuming a positive test indicates presence of a disease)?

- a. The probability of a negative test given that the person does not have the disease
- b. The proportion of people with a negative test, who are healthy
- c. The proportion of people with a positive test, who have the disease
- d. The probability of a positive test given that the person does have the disease

The correct answer is the proportion of people with a negative test, who are healthy. In order to know these proportions, it means that we need to know the rate of disease in the relevant population

### SINGLE SAMPLE, UNPAIRED, AND PAIRED T-TESTS – 5 QUESTIONS

What is NOT an underlying assumption that needs to be made when using the unpaired t-test to compare means for two populations?

- a. Dependence of samples
- b. Normality of sample distributions
- c. Equal variance between the two populations
- d. Ratio or interval data

The correct answer is dependence. For the unpaired t-test, samples must be independent from each other. The underlying restrictions and assumptions are independence, normality, equal variance, ratio or interval data, and random assignment. If these are not met, then a t-test should not be used.

An unpaired t-test compares means from two \_\_\_\_\_ samples, while the paired t-test compares the means from two \_\_\_\_\_ samples.

- a. Dependent, independent
- b. Independent, dependent

The correct answer is independent, dependent.

You have conducted an unpaired t-test, and have come to the conclusion that you have failed to reject the null hypothesis. What is the next step, if any, in your statistical analysis?

- a. There is no next step. You have come to the right conclusion
- b. Determine Power by using the equation:  $1 - \beta$
- c. Determine alpha because you may have committed a type one error

The correct answer is determine power by using the equation:  $1 - \beta$ . Rejecting the null is a negative result, so one must think if this is a true negative or a false negative. This falls into the category of a type II error, so one must determine power to ensure our conclusion is correct.

Power has relationships with standard deviation (SD), N and alpha. Power will go \_\_\_\_ as SD gets larger. Power will go \_\_\_\_ as N gets larger. Power will go \_\_\_\_ as alpha gets smaller.

- a. Down, up, up
- b. Up, down, up
- c. Down, up, down
- d. Down, down, up

The correct answer is down, up, down. If the SD is large, the data is scattered more and the sampling error is likely to produce larger differences. If you collect more evidence, sampling error is likely to produce small differences. And when alpha is made smaller, you set harsher criterion for finding a significant difference. This decreases your chance of making a type I error, but you increase the chance that a real difference will be declared non-significant.

What is a reason you would pick a t-test rather than a z-test?

- a. Sample sizes are smaller (<30)
- b. The population standard deviation is known
- c. When you are trying to make an inference about population means
- d. When the bell curve is negatively skewed

The correct answer is when you are trying to make an inference about population means. T-tests are more appropriate when sample sizes are less than 30, and the population standard deviation is unknown.

### ANOVA – 6 QUESTIONS

An infant's gaze is looking to be assessed. The question is how is an infant's time of gaze (looking at an object) affected by the type of object being viewed? The objects used are a face, a circle, a newspaper, and a white piece of paper. Which type of ANOVA test would you use to best assess this scenario?

- a. One-way ANOVA
- b. Three-way ANOVA
- c. Repeated measures
- d. Two-way ANOVA

The correct answer is repeated measures. There is a third source of variance that has been introduced. Now there are individual differences between subjects. Two-way ANOVA has two independent variables, and three-way ANOVA will have three independent variables.

Mixed design ANOVA will have at least one independent factor and at least one repeated factor.

What is the symbol for the critical value for an ANOVA test?

- a. S
- b. P
- c. Sigma
- d. F
- e. Z

The correct answer is F. The F statistic is a ratio between the variability between the group means and the variability within subjects in the same group.  $H_0$  is rejected whenever the calculated F statistic > a critical F ratio.

Which of the following assumptions will cause serious problems in an ANOVA test, if it is violated?

- a. Independence of observations
- b. Homogeneity of variance
- c. Normality
- d. Measurements on the interval or ratio scale

The correct answer is independence of observations. Normality and homogeneity of variance can be slightly violated and as long as the sample sizes are equal, then it's not a problem. However, if the measurements are dependent or not independent of each other, then this can become a serious problem in using an ANOVA.

The Bonferroni correction is when you divide alpha by the number of comparisons being performed. What type of test is in regards to?

- a. Single comparison tests
- b. Regression tests
- c. Post-hoc tests
- d. Correlation tests

The correct answer is post-hoc tests. Post hoc tests, or multiple comparison tests are required following a significant F test involving an independent variable with more than two levels. You should never simply perform multiple t-tests without using the Bonferroni correction.

Which assumption does the assumption of sphericity fall under when conducting a repeated-measures ANOVA?

- a. Normality
- b. Independence of observations
- c. Measurements on the interval or ratio scale
- d. Homogeneity of variance

The correct answer is homogeneity of variance. This is also called compound symmetry. This is the assumption that the correlations between the scores for all possible pairs of measures are equal in size. A common test for this assumption is Mauchly's test of Sphericity.

What is a potential limitation when using a repeated-measures design ANOVA?

- a. Fewer subjects are needed
- b. Fatigue, learning effects and carryover can affect outcomes
- c. Subjects serve as their own control
- d. It separates subject differences from error

The correct answer is fatigue, learning effects and carryover can affect outcomes. All of these have the potential of contaminating or obscuring the true effect of the treatments on the dependent measure. The separation of subject differences from error gives us a more power test, which is an advantage of a repeated-measures design.

### CORRELATION AND REGRESSION ANALYSIS – 7 QUESTIONS

What is the major goal when it comes to a linear regression?

- a. Find where the data points cross
- b. Calculating the y-intercept at any given point
- c. Finding the line of best fit
- d. To make the scatter plot as neat as possible

The correct answer is finding the line of best fit. You usually want to be able to predict values of the dependent variable from values of the independent variable. You can also determine how much of the variability in the data can be explained from the linear trend.

In a linear regression, the Y-variable is the \_\_\_\_\_ variable, and the X-variable is the \_\_\_\_\_ variable.

- a. Independent, dependent
- b. Dependent, independent

The correct answer is dependent, independent. Regression analysis is a technique used to predict the value of one variable (the dependent) based on the value of other variables (independent).

$$y = b_0 + b_1x + e$$

The first order linear model is  $y = b_0 + b_1x + e$ . What does  $b_1$  represent?

- The Y-intercept
- The error variable
- The dependent variable
- The slope of the line

The correct answer is the slope of the line. Typically the Y-intercept and the slope of the line are unknown and estimated from the data.

Pure error lack-of-fit tests enable you to check the straight line fit of your model. \_\_\_\_\_ F-values and \_\_\_\_\_ p-values suggest that the model is inadequate.

- Small, large
- Large, small
- Small, small
- Large, large

The correct answer is large, small.

A scatter plot containing heteroscedasticity will do what towards the end of its graph?

- Be a uniformed straight line
- Fan out
- Nothing
- Zig-zag

The correct answer is fan out. This happens when the requirement of a constant variance is violated. This makes the hypothesis tests invalid.

Which of the following is NOT an assumption for a multiple linear regression?

- Normality of residuals
- Linearity
- Variables are measured without error

d. Heteroscedasticity

The correct answer is heteroscedasticity. Multiple linear regressions are similar with simple linear regressions where they need to maintain homoscedasticity, or a constant variance.

What is  $R^2$  called?

- a. The coefficient of squares
- b. The Durbin coefficient
- c. The coefficient of determination
- d. The coefficient of concentration

The correct answer is the coefficient of determination. For multiple linear regression, it is also called the coefficient of multiple determination. It is the proportion of variation in Y 'explained' by all X variables taken together.

### NON-PARAMETRIC STATISTICS – 5 QUESTIONS

Which of these best describes an aspect of a non-parametric test, and not a parametric test?

- a. Equal variance
- b. Can be used with ordinal or nominal data
- c. Can't be used with low sample sizes
- d. Assumes a given parameter for the population

The correct answer is can be used with ordinal or nominal data. Non-parametric tests can also be used with low sample sizes, very skewed distributions or when the population variances are not homogeneous. These tests are usually less powerful than parametric tests.

Which of these tests is not a non-parametric test?

- a. Wilcoxon Ranked-Sum test
- b. Linear regression
- c. Friedman Two-way ANOVA
- d. Kruskal-Wallis

The correct answer is the Linear regression.

Why would someone NOT chose to use a non-parametric test?

- a. If data allows using parametric procedures
- b. Because non-parametric tests can be used with all measurement scales
- c. Because non-parametric tests make few assumptions with good results
- d. It does not need to involve population parameters

The correct answer is if data allows using parametric procedures. If the data set allows for a parametric test to be ran, then it should be prioritized over running a non-parametric test. Non-parametric tests tend to be less systematic, and less powerful than parametric tests.

What size of table data is preferred when using the Fisher's Exact test?

- a. 3x3
- b. 5x5
- c. 4x4
- d. 2x2

The correct answer is a 2x2 table. In addition to a 2x2 contingency table, it is most appropriate when at least one frequency is less than 5.

The Wilcoxon rank-sum test and the Wilcoxon signed-rank test are similar in name, but require different specifications in samples. The Wilcoxon rank-sum test needs \_\_\_\_\_ samples, while the Wilcoxon signed-rank test needs \_\_\_\_\_ samples.

- a. Dependent, independent
- b. Independent, dependent

The correct answer is independent, dependent. The Wilcoxon rank-sum test (Mann-Whitney U test) is the non-parametric counterpart for the t-test of independent samples. Typically, the measurement scale is at least ordinal and the dependent variable is continuous. The Wilcoxon signed-rank test is the non-parametric version of the paired t-test. This is used when the normality assumption is violated.

## Appendix D: Quizlet ClinECP4 – Questions and Answers

This appendix features all the multiple-choice questions and answers created for the Clinical Extracorporeal Perfusion IV course that were uploaded to Quizlet.

### Clinical Extracorporeal Perfusion IV

#### EVIDENCE-BASED MEDICINE – 5 QUESTIONS

In the last 30 years, vast improvements to which driving force has enabled the most advancements in evidence-based medicine?

- a. Emphasis on cost reduction
- b. Increased use of randomized trials
- c. Growth of clinical research
- d. Use of information systems and technologies

The correct answer is the use of information systems and technologies. These improvements have made it such that technology is not holding us back, but we are.

Which of the following is not a step in evidence based medicine?

- a. Guess as to what could be causing the patient's problem and treat accordingly
- b. Search literature for relevant clinical articles
- c. Evaluate the evidence for validity
- d. Implement useful findings in clinical practice

The correct answer is guess as to what could be causing the patient's problem and treat accordingly. The real step of evidence-based medicine is to formulate a clear clinical question based on the patient's problem.

Typically, how does perfusion fit into the system of evidence-based medicine?

- a. Perfusionist do not question others. We trust their experience and knowledge
- b. Perfusionists keep data and store this into databases
- c. We never perform any maintenance on our pumps, heater coolers or TEG machines
- d. We do things old school because we don't fix what isn't broken

The correct answer is perfusionists keep data and store this into databases. We are encouraged to keep up to date with new trends of the industry. We control cost, and constantly practice quality control.

When searching for current trends and research articles regarding to the field of perfusion, what type of sources should be used and trusted?

- a. Podiatry registries
- b. Surgeon's Society of Thoracic Findings
- c. Society of Cardioverting Anesthesiologists
- d. AmSECT

The correct answer is AmSECT. AmSECT is one of many professional organizations that help set standards and guidelines for practicing perfusionists. Other groups that have relevant and applicable information to perfusionists can be found from the Society of Thoracic Surgeons (STS), or the Society of Cardiovascular Anesthesiologists (SCA). The remaining answers are abbreviated wrong or have nothing to do with the field of perfusion.

When referring to AmSECT standards and guidelines, what classifications levels provide the strongest quality of evidence?

- a. Class 1A
- b. Class 2aB
- c. Class 4A
- d. Class 4D

The correct answer is Class 1A. Class 1 is represented by a strong level of recommendation. Class 4 is in the harm category, so avoid that at all costs. Level A is the highest quality of evidence, and level C is the lowest.

## **BUSINESS AND LEGAL ASPECTS OF PERFUSION – 6 QUESTIONS**

Quality assurance is based upon 5 principles. Which of the follow is NOT one of these principles?

- a. Successful QA requires both individual and organization commitment to develop values for excellence
- b. The responsibility for excellence must be maintained by the chiefs and executives to ensure the prosperity and best-practice of the hospital
- c. QA requires a comprehensive approach to education, administration and support services for all groups in the hospital

- d. QA should be continuously monitored for its effectiveness and adaptiveness towards current organizational needs

The correct answer is the responsibility for excellence must be maintained by the chiefs and executives to ensure the prosperity and best-practice of the hospital. This responsibility must be distributed so that a variety of authorized medical personnel have the power to review and implement any necessary changes.

What is NOT another name for quality improvement?

- a. Total quality management
- b. Quality control
- c. Quabbity assuance
- d. Continuous quality improvement

The correct answer is quabbity assuance. Quality improvement is the philosophy of health care professionals to address and correct problems identified through the implementation of QA.

Which agency protects the use and disclosure of protected health information?

- a. JCAHO
- b. OSHA
- c. CAP
- d. HIPAA

The correct answer is HIPAA. HIPAA stands for the Health Insurance Portability and Accountability Act. In 2000, the DHHS came out with a statement that HIPAA will establish patient control over their health records and information. Adherence to HIPAA laws are crucial and if violate, can end in a law suit.

What technique will NOT help a perfusionist remain within the legal scope of perfusion practice?

- a. Removing the level alarm sensor because it keeps going off
- b. Maintain well-kept records of the case
- c. Continuing education within the field to improve patient care

The correct answer is removing the level alarm sensor because it keeps going off. Safety devices are there for the perfusionist's and the patient's protection. While these may be inconvenient at times, ensure these safety devices are on at all times to maintain good patient care.

What primary element of medical negligence is an action of commission or omission by the professional that violates previously established standards of patient care?

- a. Duty
- b. Damage
- c. Proximity of Cause
- d. Breach of Duty

The correct answer is breach of duty. Duty is when a medical professional owed the patient a responsibility to act in a proper manner, considering the situation, circumstances and standards established by the profession. Proximity of cause is a specific action by the professional which directly resulted in injury to the patient. Damage is the patient indeed suffered quantifiable losses or damages as a direct result of the injury.

Which of these is NOT a new role that is emerging for perfusion chiefs?

- a. The designer
- b. The developer
- c. The strategist
- d. The leader

The correct answer is the developer. The designer addresses matters in an organizational structure and supervises production, information systems, etc. The strategist monitors and analyzes environmental signals, and estimates the impact of an environmental signal on the organization and its shareholders. The leader plays a key role in ensuring that the employees know, understand and accept the core values of the organization.

#### **TECHNIQUES FOR EXAM PREPERATION – 4 QUESTIONS**

How many clinical, independent cases must one have in order to take the CAPE?

- a. 20
- b. 60
- c. 40
- d. 50

The correct answer is 40. These cases must be dated after the official graduation date listed on their transcript.

Which of the following subjects is NOT part of the knowledge base listed on the ABCP website?

- a. Pathology
- b. Quality Assurance
- c. Anatomy and Physiology
- d. None of the above

The correct answer is none of the above. All of these topics are on the ABCP board exams. In addition to these, pharmacology, laboratory analysis, device and equipment, clinical management, special patient groups, ECMO, ECLS, catastrophic events and device failure and monitoring can all be found on the CAPE and PBSE.

What is the lowest level of understanding?

- a. Comprehension
- b. Knowledge
- c. Synthesis
- d. Evaluation

The correct answer is comprehension. This includes explaining, summarizing, and estimating the effects of data. Knowledge is the lowest level of learning. Synthesis is the ability to combine the parts to construct a new entity, and evaluation represents actions, decision making, or selections according to a discrete set of criteria.

What does the second R stand for in the SQRRR method of study?

- a. Respond
- b. Review
- c. Read
- d. Recite

The correct answer is recite. SQRRR means to survey, question, read, recite and review.

## Appendix E: Quizlet Ancillary Perfusion and Operating Room – Questions and Answers

This appendix features all the multiple-choice questions and answers created for the Clinical Extracorporeal Perfusion IV course that were uploaded to Quizlet.

### Ancillary Perfusion and Operating Room

#### ANCILLARY PERFUSION AND OPERATING ROOM QUESTIONS – 12 QUESTIONS

What heart structure does the Impella CP partially or fully bypass?

- a. Right ventricle
- b. Aorta
- c. Left ventricle
- d. Pulmonary artery

The correct answer is left ventricle. The Impella ventricular support systems are left-sided heart pump systems that help give left ventricular support for up to 6 days [1].

Which of the following disease states would best fit the need to use an Impella?

- a. Cardiogenic shock
- b. Respiratory failure
- c. Endocarditis
- d. Dilated cardiomyopathy

The correct answer is cardiogenic shock. In cardiogenic shock, the left heart is not capable of pumping enough blood to satisfy the demands of the body. This results in progressive damage to organs and possibly death. Clinical evidence has shown that 58% of patients with cardiogenic shock who received the Impella survived the procedure, and 67% of patients who left the hospital had myocardial recovery [1].

Which of these conditions is NOT a contraindication to use an Impella?

- a. Clots in the left side of the heart
- b. Having a replacement valve
- c. Aortic regurgitation

d. Myocardial infarction

The correct answer is myocardial infarction. Clots in the left side of the heart can break off and clot the pump, which can result in harm. A replacement valve can block the open area available for the pump to pass. Aortic regurgitation can cause the heart to work harder over time and decrease the ability of the heart to supply oxygenated blood to the rest of the body [1].

When considering V-V ECMO, which of the following cannulas would not be ideal to use?

- a. Protek Duo
- b. 17 FR HLS Cannula
- c. Avalon
- d. Crescent

The correct answer is the 17 FR HLS cannula. The Protek duo, Avalon and the Crescent are all dual lumen cannulas that insert into the RIJ. These cannulas require only one cannulation site, which is better for maintenance and patient care [2, 3, 4, 5].

A persistent left SVC may drain into which structures?

- a. Right atrium
- b. Coronary Sinus
- c. Left atrium
- d. A and B
- e. A, B and C

The correct answer is A, B, and C. The PLSVC is formed when the left superior caudal vein fails to regress. Typically, there is a normal right SVC, but in rare cases, the PLSVC is the only vessel draining the upper body. It can drain into these 3 structures via an unroofed coronary sinus [6].

In which type of case may a Gott shunt be used?

- a. OPCAB
- b. Descending thoracic aneurysms
- c. Lead extractions
- d. Coronary artery ruptures

The correct answer is descending thoracic aneurysms. This can also be used for a thoracoabdominal aneurysm. The Gott shunt is a flexible tube that is used to direct blood around a clamped out area of the aorta. The shunt is attached above the superior clamp and below the distal clamp, allowing blood to bypass the damaged section of the aorta [7].

What site is the most common place to find an atrial myxoma?

- a. The right atrium, near the opening for the SVC and IVC
- b. The left ventricle on the inferior, towards the apex of the heart

- c. The right ventricle on the anterior side, near the tricuspid valve
- d. The left atrium, near the interatrial septum

The correct answer is the left atrium, near the interatrial septum. About 86% of atrial myxomas occur in the left atrium. These are common primary heart tumors and are removed by surgical resection [8,9].

AngioVac is used for the removal of what type of substance?

- a. Vegetation
- b. Emboli
- c. Thrombi
- d. All the above

The correct answer is all the above. The AngioVac cannula is indicated as a venous drainage cannula for soft, fresh thrombi, emboli or vegetation for up to 6 hours [10].

AngioVac cannulas can be used to remove vegetation caused by endocarditis. Which patient population is especially at high risk for developing endocarditis?

- a. Pregnant patients
- b. Diabetic patients
- c. Intravenous drug abusers
- d. Obese patients

The correct answer is Intravenous drug abusers. Methicillin sensitive *Staphylococcus aureus* is the most common etiological microbial agent of infective endocarditis in drug abusers. Quickly, the patient can be septic [11].

Vegetation from endocarditis most commonly affects which valve in the heart?

- a. Mitral
- b. Tricuspid
- c. Aortic
- d. Pulmonary

The correct answer is tricuspid. Aortic and mitral valves can be affected, but the primary valve that is most affected by endocarditis is the tricuspid.

When operating a cell saver during a Cesarean section delivery, suction of what substance is of main concern?

- a. Amniotic fluid
- b. Blood
- c. Fat
- d. Bone

The correct answer is amniotic fluid. Amniotic fluid is more dense than RBCs. The cell saver cannot differentiate between RBCs and amniotic fluid, so it will process it and pack

it. If given back to the patient, this can cause an amniotic fluid embolism and severely harm the patient.

Which of the following is NOT an indication for using the Cardiohelp System?

- a. Septic shock
- b. ARDS
- c. Bridge to lung transplant
- d. Circulatory failure
- e. Myocardial infarction
- f. Pulmonary embolism
- g. None of the above

The correct answer is none of the above. The Cardiohelp can be used as a VA or VV ECLS. It is very portable, which helps with ground/air transport. It is approved for ECLS support for up to 30 days [12].

## References for Appendix E

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## Appendix F: Practice Exams – Questions and Answers

This appendix features all the multiple-choice questions and answers created for Practice Exams 1-4 that was uploaded to Quizlet.

### PRACTICE EXAMINATIONS ONE THROUGH FOUR

#### PRACTICE EXAM 1 – 100 QUESTIONS AND ANSWERS

1. Fetal blood is mostly oxygenated in the
  - a) Fetus's heart
  - b) Mother's lungs
  - c) Fetus's lungs
  - d) Placenta
  
2. Which of the following is NOT true regarding  $\alpha$  – stat blood gas management?
  - a) Cerebral response to pCO<sub>2</sub> preserved
  - b) Autoregulation of cerebral vessels remains intact
  - c) Cerebral blood flow increases
  - d) Intracellular pH remains neutral
  - e) Myocardial protection is better relative to pH – stat
  
3. The primary transmitter at parasympathetic postganglionic nerve endings is
  - a) Acetylcholine
  - b) Enkephalin
  - c) GABA
  - d) Nitric Oxide
  - e) Norepinephrine
  
4. Some sources employ using  $\alpha$  – stat management strategies and pH – stat management strategies during different parts of hypothermic procedures to optimize the benefits from both strategies. Which of the following best describes this method of blood gas management?
  - a) Cool and rewarm with  $\alpha$  – stat and then switch over to pH – stat once normothermic
  - b) Cool with  $\alpha$  – stat and then switch over to pH – stat
  - c) Cool and rewarm with pH – stat and then switch over to  $\alpha$  – stat once normothermic

- d) Cool with pH – stat and then switch over to  $\alpha$  – stat
  - e) Cool with  $\alpha$  – stat until deep hypothermia then switch over to pH – stat. Once out of deep hypothermia, switch back to  $\alpha$  – stat.
5. Which of the following is NOT a VA ECMO cannulation site?
- e. Cervical
  - f. Sternal
  - g. Femoral
  - h. Right IJ
6. AngioVac is used for the removal of what type of substance?
- e. Vegetation
  - f. Emboli
  - g. Thrombi
  - h. All the above
7. Which of the following is NOT a procedure to fix hypoplastic left heart syndrome?
- e. Norwood
  - f. Bidirectional Glenn
  - g. Fontan
  - h. Ebstein
8. For every unit of platelets transfused, you can expect the recipient's platelet count to rise by:
- a) 5,000 to 10,000 platelets per uL
  - b) 15,000 to 20,000 platelets per uL
  - c) 25,000 to 50,000 platelets per uL
  - d) 50,000 to 100,000 platelets per uL
9. Which of the following is an advantage of using neonatal VA ECMO?
- e. Emboli will go to the lungs rather than the brain
  - f. Provides the ability to support systemic perfusion in lung/cardiac failure
  - g. Preserve Pulsatility with adequate cardiac function
  - h. No need to enter or ligate a carotid artery
10. Stimulation of which of the following will secrete a hormone that can increase heat production when you are cold?
- a) Thymus
  - b) Thyroid
  - c) Pancreas
  - d) Thalamus
  - e) Spleen

11. What anatomical structure separates the thoracic and abdominal aorta?
- Stomach
  - The inferior aspect vertebra T12
  - Diaphragm
  - Pancreas
  - Renal artery origin
12. The femoral artery is an immediate continuation of the
- Abdominal aorta
  - Thoracic aorta
  - External iliac artery
  - Internal iliac artery
13. Using the same information from the previous question, you decide to prime with packed red blood cells (PRBCs, Hct = 70%) to obtain a goal hematocrit of 26%. How many mL of PRBCs should be given to achieve this? (70 kg male patient, with a hematocrit of 28% and a circuit priming volume of 1800 mL)
- 710 mL
  - 350 mL
  - 410 mL
  - 590 mL
  - 460 mL
14. Which of the following ions plays an important role in the buffering system of blood?
- Sodium
  - Potassium
  - Chloride
  - Magnesium
  - Calcium
15. Which of the following statements is NOT true regarding bioprosthetic valves?
- Leaflets composed of porcine pericardium
  - Requires anticoagulation therapy
  - Last about 15 – 20 years
  - Allows for physiologic blood flow
  - Chemically inert
16. Binding of antibodies to antigens inactivates antigens by all of the following, except
- Opsonization
  - Agglutination

- c) Precipitation
- d) Complement fixation
- e) Saponification

17. The volume that can be expired after the expiration of a tidal volume is

- a. Tidal volume
- b. Inspiratory reserve volume
- c. Expiratory reserve volume
- d. Residual volume
- e. Dead space

18. A solution that has a higher concentration of solutes than a cell with a semi-permeable membrane is most likely:

- a) Hypotonic
- b) Hypertonic
- c) Isotonic
- d) Isosmotic
- e) Hypo-osmotic

19. What is the primary mechanism of action by which warfarin can induce its effects?

- a. Increases the plasma level of factor IX
- b. Inhibits thrombin
- c. Inhibits prothrombin synthesis and factors VII, IX, and X
- d. Inhibition of platelet aggregation in vitro
- e. Activation of plasminogen
- f. Binding of Calcium ion cofactor in the coagulation cascade

20. What anticoagulation test is used to monitor heparin therapy?

- a) Bleeding time
- b) aPTT
- c) PT
- d) INR
- e) Thrombin time

21. During CPB, your patient exhibits an unexplained increase in temperature and an unexplained metabolic and respiratory acidosis. Which of the following conditions do you suspect your patient has?

- a) Thalassemia
- b) Cold agglutinins
- c) Methemoglobinemia
- d) Malignant hyperthermia
- e) Sickle cell anemia

22. What is the traditional loading dose of heparin for bypass?
- 250 – 350 U/kg
  - 200 – 400 U/kg
  - 300 – 400 U/kg
  - 50 – 150 U/kg
  - 100 – 150 U/kg
23. The mechanism of action of which drug decreases glucose synthesis in the liver and increases glucose utilization by muscle?
- Sulfonylureas
  - Meglitinides
  - Biguanides
  - Thiazolidinediones
  - Alpha-glucosidase inhibitors
24. A 34-year-old male gets gas in his pleural space. This is likely to cause
- Pneumothorax
  - Hemothorax
  - Chylothorax
  - Lipothorax
25. AIDS can be diagnosed when
- A patient tests positive for HIV on both ELISA and Western Blot
  - An HIV positive patient's CD4 count drops below 400 cells/uL
  - A patient tests positive for HIV on one blood test
  - An HIV positive patient develops tuberculosis and Kaposi's sarcoma
  - An HIV positive patient's T cell count drops below 400 cells/uL
26. You want to use vacuum assisted hemoconcentration to pull off volume faster. Your arterial line pressure is 300 mmHg. Which of the following would be an appropriate amount of vacuum to apply to your hemoconcentrator?
- 50 mmHg
  - 150 mmHg
  - 250 mmHg
  - 350 mmHg
  - 400 mmHg
27. The majority of carbon dioxide is transferred out of the blood
- In bicarbonate
  - Bound to amino acids in hemoglobin

- c) Dissolved in plasma
  - d) As oxygen
28. You have a morbidly obese patient that needs CPB. The gas exchange capacity of your oxygenator will not be enough to sustain adequate gas transfer for the patient, so you decide you are going to place an additional oxygenator in \_\_\_\_\_.
- a) Parallel
  - b) Series
29. At what percent occlusion of the coronary arteries will an individual typically start becoming symptomatic?
- a) 10%
  - b) 25%
  - c) 40%
  - d) 70%
  - e) 100%
30. Which of the following thromboelastograph (TEG) parameters describes the strength of a clot?
- a) R-value
  - b) K-value
  - c) MA
  - d)  $\alpha$  angle
  - e) LY30
31. Which of the following is most responsible for cell lysis?
- a) C5b-C9
  - b) C3b
  - c) C5a
  - d) C3a
32. Which of the following cardioplegia constituents is an intermediary in the citric acid cycle that is used to help replenish ATP stores?
- a) Mannitol
  - b) Nicorandil
  - c) Adenosine
  - d) Lidocaine
  - e) Aspartate
33. What is the purpose of the pre-bypass filter?
- a) To filter out manufacturer debris
  - b) To filter the patient's blood as it comes through the venous line
  - c) To filter out prime drugs
  - d) To filter out circuit coating

34. For a DHCA case, if you only have one arterial pressure monitoring line and you are cannulating axillary, which of the following will be the location of that monitoring line?
- Right femoral
  - Left femoral
  - Right radial
  - Left radial
35. What organ system frequently affected post lung transplant due to chronic RV dysfunction?
- Pancreas
  - Spleen
  - Liver
  - Stomach
  - Appendix
36. Which of the following is NOT true regarding restrictive lung diseases?
- FVC is reduced
  - FEV1: FVC ratio is near normal
  - Characterized by increased compliance
  - ARDS is considered a restrictive lung disease
  - Pulmonary fibrosis is considered a restrictive lung disease
37. Increasing pCO<sub>2</sub> has what effect on cerebral blood flow (CBF)?
- Increases CBF
  - Decreases CBF
38. When a single synapse receives many excitatory postsynaptic potentials at the same time, it is called
- Temporal summation
  - Spatial summation
  - Zonal summation
  - Neuron integration
39. For a patient, who is 3 years old, what number cardiac index number times their BSA would you suggest maintaining given you have the means to do so?
- 3.2 index
  - 2.5 index
  - 2.8 index
  - 2.4 index
40. In July of 1952, who performed the first successful total left-sided heart bypass?
- Lillehei
  - Debaek
  - Dudley Johnson
  - Dodrill
  - Gibbon

41. What does a ratio of 1:3 mean on an IABP?
- 1 IABP assisted beat for every 2 beats
  - 1 IABP assisted beat for every 4 beats
  - 1 IABP assisted beat for every 3 beats
42. Which of these benefits is NOT a major reason to use MUF?
- Removal of potassium
  - Removal of inflammatory mediators
  - Increasing hematocrit
  - Improving ventricular functional recovery
43. In 1918, the name heparin was dubbed by whom?
- Carrel & Lindbergh
  - Chargraff & Olson
  - von Frey & Gruber
  - Howell & Holt
  - Dodrill
44. Non-pulsatile perfusion increases the production of \_\_\_\_\_ hormone levels which increases vasopressin production, shutting off distal capillary beds.
- Angiotensin II
  - Serotonin
  - Cortisol
  - Thyroid
  - Adrenaline
45. Cold agglutinins are caused by which antibody?
- IgA
  - IgE
  - IgM
  - IgG
  - IgD
46. Which of the following is a viable cardioplegia protocol for patients with cold agglutinins?
- Warm induction with microplegia until the heart arrests. Then switch over to cold microplegia until a hot-shot should be given before cross-clamp removal
  - Administer 300 mL of warm crystalloid cardioplegia, then switch over to cold crystalloid for the remainder of the dose. Give a hot-shot before cross-clamp removal
  - Administer 300 mL of warm 1:4 del Nido cardioplegia, then switch over to cold crystalloid for the remainder of the dose. Switch back over to 1:4 del Nido cardioplegia for hot-shot before cross-clamp removal
  - Administer cold crystalloid cardioplegia for all doses in the case
47. The IVC develops from which of the following segments?
- Renal segment
  - Hepatic segment

- k. Post-hepatic segment
  - l. Pre-renal segment
  - m. Splanchnic segment
  - n. Post-renal segment
  - o. A, B, C, D
  - p. A, B, D, F
  - q. C, E, F, D
48. Certain conditions are not well tolerated for the increased CO associated with CPB and thus are contraindicated for. These include all the following, EXCEPT?
- a) Coarctation of the aorta
  - b) Pulmonary hypertension
  - c) Marfan's syndrome
  - d) Aortic aneurysm
  - e) Mitral regurgitation
49. You can anticipate that all the following would usually increase systemic vascular resistance (SVR), except:
- a) Hypothermia
  - b) Increased hematocrit
  - c) Closure of portions of the microvasculature
  - d) Cardioplegia
50. What is the normal range for jugular venous oxygen saturation (JvO<sub>2</sub>)?
- a) 80 – 90%
  - b) 60 – 70%
  - c) 50 – 60%
  - d) 90 – 100%
51. Which of the following is considered the connection between the nervous system and the endocrine system?
- a) Pituitary gland
  - b) Hypothalamus
  - c) Thalamus
  - d) Mammillary bodies
  - e) Brainstem
52. What would be an appropriate flow rate for ostial delivery of cardioplegia?
- a) 90 -110 mL/min
  - b) 150 – 200 mL/min
  - c) 300 – 400 mL/min
  - d) 250 – 300 mL/min
  - e) 10 – 40 mL/min
53. Which of the following receptors is responsible for increasing motility of the GI tract?

- a) Alpha 1
- b) Alpha 2
- c) Beta 1
- d) Beta 2
- e) Muscarinic 2
- f) Muscarinic 3
- g) Nicotinic (n)
- h) Nicotinic (m)

54. You have a patient that needs ascending aortic surgery. Which of the following patients would most likely get a composite graft?

- a) Patient's aortic valve annulus is enlarged and valve incompetent
- b) Patient's aortic valve annulus is normal and valve competent
- c) Patient's aortic valve annulus is normal and valve incompetent
- d) More than one of the above

55. What type of variable affects the testing method itself?

- a) Post-analytical
- b) Pre-analytical
- c) Analytical

56. Which of the following describes the changes in hemodynamics associated with protamine reactions?

- a) ↑ PA pressure and CVP, ↓ systemic arterial pressure
- b) ↑ CVP, ↓ PA, and systemic arterial pressures
- c) ↑ systemic arterial pressures, ↓ CVP and PA pressure
- d) ↑ systemic arterial and PA pressures, ↓ CVP
- e) ↑ systemic arterial pressure, PA pressure, and CVP

57. Which of the following expresses CD8 protein?

- a) Helper T Cell
- b) Cytotoxic T Cell
- c) Macrophages
- d) Memory B Cell
- e) Natural Killer Cells

58. Which of the following electrolytes has the highest concentration in plasma?

- a. Calcium
- b. Sodium
- c. Potassium
- d. Chloride
- e. Magnesium

59. Which type of protamine reaction activates the classic complement pathway?

- a) Histamine reaction
- b) Anaphylactic reaction

- c) Anaphylactoid reaction
  - d) Pheresis reaction
60. What is the normal range for prothrombin time?
- a) 10 – 15 seconds
  - b) 11 – 13 seconds
  - c) 2 – 3 seconds
  - d) 30 – 40 seconds
  - e) 1 – 8 minutes
61. Which of the following considerations is paramount in Jehovah's Witness patients that need CPB?
- a) Temperature management
  - b) Pressure management
  - c) Blood conservation
  - d) pH management
  - e) Arrest agent used
62. What site is not a usable site for a temperature probe?
- e. Esophageal
  - f. Rectal
  - g. Femoral
  - h. Tympanic
63. What is the difference in membrane thickness ( $\mu\text{m}$ ) of a natural lung versus membrane lung?
- a) Natural lung: 0.5, membrane lung: 150
  - b) Natural lung: 3.0, membrane lung: 100
  - c) Natural lung: 10, membrane lung: 200
  - d) Natural lung: 15, membrane lung: 70
  - e) Natural lung: 0.2, membrane lung: 140
64. All of the following are characteristic similarities between cardiac and skeletal muscle, EXCEPT:
- a) Striated
  - b) Uses troponin
  - c) Syncytial
  - d) Can be regulated by the nervous system
  - e) Length-tension relationship
65. What is the role of the scrub tech in the OR?
- a) Helps prepare the monitoring lines, labs, and assists anesthesia
  - b) Directly assist the surgeon at the table
  - c) Organizes and hands instruments at the table

- d) Vein harvesting, assist the surgeon, etc.
66. Which of the following is not an inotrope?
- e. Dopamine
  - f. Isoproterenol
  - g. Milrinone
  - h. Epinephrine
67. Which of the following drugs may cause reflex tachycardia if given to a patient already on a nitroglycerin tablet for angina pectoris?
- a. Ace inhibitor
  - b. Beta blocker
  - c. Verapamil
  - d. Diltiazem
  - e. Nifedipine
68. What criteria would exclude a pediatric patient to be eligible for ECLS?
- e. Less than 10 days of mechanical ventilation
  - f. Gestational age >34 weeks
  - g. Evidence of severe refractory respiratory failure
  - h. An intracranial hemorrhage of a grade I or II
69. The reference position for hemodynamic monitoring during cardiac surgery is where?
- a) Right atrium
  - b) Right ventricle
  - c) Left atrium
  - d) Left ventricle
  - e) Base of aorta
70. What information MUST be covered in the OR during a "Time Out"?
- a) Patient identity, patient history, surgical procedure to be done, signed consent form
  - b) Allergies, signed consent form, surgical procedure to be done, laboratory values
  - c) Surgical procedure to be done, list of patient medications, signed consent form, allergies
  - d) Signed consent form, surgical procedure to be done, patient identity, allergies
71. Which of the following is NOT a reason for a terminal warm dose of cardioplegia?
- a) Uniformly re-warm the heart
  - b) Flush out metabolic byproducts and air
  - c) Provide arrest for early reperfusion
  - d) Activates the SA node for myocardial reanimation
  - e) Replace high energy phosphates
72. A high school athlete is in training and collapses of a sudden cardiac death. A genetic mutation in myosin protein is suspected. This individual most likely had

- a) Dilated cardiomyopathy
  - b) Hypertrophic cardiomyopathy
  - c) Restrictive cardiomyopathy
  - d) Pancarditis
  - e) Myocarditis
73. When should the first blood gas be drawn after going on pump?
- a) 5 – 20 minutes
  - b) 1 – 10 minutes
  - c) 3 – 5 minutes
  - d) 5 – 15 minutes
  - e) 1 – 20 minutes
74. What site is the most common place to find an atrial myxoma?
- e. The right atrium, near the opening for the SVC and IVC
  - f. The left ventricle on the inferior, towards the apex of the heart
  - g. The right ventricle on the anterior side, near the tricuspid valve
  - h. The left atrium, near the interatrial septum
75. All the following may help decrease potassium levels during CPB, except
- a) Furosemide
  - b) Dextrose
  - c) Sodium bicarbonate
  - d) Zero-balance ultrafiltration
76. Which of the following statements is true?
- a) Venous reservoirs have a positive pressure relief valve at +50 mmHg
  - b) Venous reservoirs are designed for low flow rates
  - c) Cardiomy reservoirs are specifically designed for air handling
  - d) Venous reservoirs have a negative pressure relief valve at -300 mmHg
  - e) Cardiomy reservoirs are specifically designed for gross filtration and de-foaming
77. What anticoagulation test is used to monitor heparin therapy?
- a) Bleeding time
  - b) aPTT
  - c) PT
  - d) INR
  - e) Thrombin time
78. Which of the following is mostly considered a response from the sympathetic nervous system?
- a. Increased glandular secretions
  - b. Glycogenolysis
  - c. Meiosis

- d. Bronchoconstriction
- e. Slowing of the heart rate

79. Of the following, which has the lowest interstitial fluid osmolarity?

- a) Descending loop of Henle
- b) Thin ascending limb of Loop of Henle
- c) Thick ascending limb of Loop of Henle
- d) Distal convoluted tubule
- e) Collecting duct

80. What percentage of total body weight is from plasma?

- a) 7-8%
- b) 20%
- c) 80%
- d) 30-40%
- e) 60-65%

81. The first set of blood gasses should be drawn within how many minutes of going on pump?

- a) 5 minutes
- b) 10 minutes
- c) 15 minutes
- d) 20 minutes
- e) 30 minutes

82. Some manufacturers for IABPs allow a 1:8 option. Why is this a problem?

- a) Increases risk of thrombus formation
- b) Increases risk of distal limb ischemia
- c) Increases risk of compartment syndrome
- d) Increases risk of kidney failure
- e) Increases risk of infection

83. A patient has a pH of 7.28, a  $p\text{CO}_2$  of 41, and a  $\text{HCO}_3^-$  of 17. This patient most likely has:

- a) Respiratory depression
- b) Hyperventilation
- c) Renal failure
- d) Sodium Bicarbonate overdose

84. In the 1930s, who developed the first sterile pulsatile perfusion system (i.e., the first blood pump)?

- a) Carrel & Lindbergh
- b) Castellanos & Robb
- c) Henry & Jouvelet

- d) Gibbon
  - e) DeWall
85. Mild to moderate hypotension secondary to rapid administration of protamine is which of the following types of protamine reactions?
- a) Type A
  - b) Type B
  - c) Type C
86. The conus artery is
- a) The small first branch of the right coronary artery in some people
  - b) The middle branch of the left coronary artery in some people
  - c) A possible third main coronary artery
  - d) A branch of the left anterior descending artery
87. Which of the following is not a treatment for atrial arrhythmias?
- a) Carotid sinus massage
  - b) Adenosine
  - c) Verapamil
  - d) Cardioversion
  - e) Epinephrine
88. The driving force that is the ultimate determinant of a hemoconcentrator's filtration rate is the
- a) Vacuum pressure
  - b) Transmembrane pressure
  - c) Arterial line pressure
  - d) Pore size
89. Match the synapse with its mode of action
- a. Excitatory cholinergic synapse ; NE
  - b. Inhibitory GABA-ergic synapse ; ACh
  - c. Excitatory adrenergic synapse ; NE
  - d. Excitatory cholinergic synapse ; GABA
90. What would be an appropriate flow rate for vein graft delivery of cardioplegia?
- a) 300 – 400 mL/min
  - b) 50 – 100 mL/min
  - c) 250 – 300 mL/min
  - d) 150 – 200 mL/min
  - e) 100 – 300 mL/min
91. With regards to cardiac looping, which of the following is true?

- e. D-looping is when the LV is positioned leftward, and L-looping is when the LV is positioned rightward
  - f. L-looping is when the LV is positioned leftward, and D-looping is when the LV is positioned rightward
  - g. D-looping is when the RV is positioned leftward, and L-looping is when the RV is positioned rightward
  - h. L-looping is when the RV is positioned leftward, and D-looping is when the RV is positioned rightward
92. Administering protamine to which side of circulation may reduce the risk of a protamine reaction?
- a) Right-sided administration
  - b) Left-sided administration
93. Clopidogrel inhibits platelet function by what mechanism of action?
- a) ADP receptor blocking
  - b) GP IIb/IIIa receptor blocking
  - c) Cyclooxygenase inhibition
94. Which of the following is NOT true regarding veno-venous bypass?
- a) Risk of renal failure is reduced
  - b) Normal cardiac physiology is maintained
  - c) Safe time for anhepatic phase is reduced
  - d) Portal venous system is decompressed
95. Where does blood flow within hollow fiber hemoconcentrators?
- a) Inside of the fibers
  - b) Outside of the fibers
  - c) Initially inside the fibers and then it is pushed out
  - d) Initially outside the fibers and then it is pushed in
  - e) None of the above
96. How much blood flow do the coronaries receive and when?
- a) ~125 mL/min during systole
  - b) ~125 mL/min during diastole
  - c) ~225 mL/min during systole
  - d) ~225 mL/min during diastole
  - e) ~400 mL/min during systole
  - f) ~400 mL/min during diastole
97. You have a patient that is peripherally cannulated for VA ECMO via the femoral artery and femoral vein. What peripheral monitoring site should you choose to monitor the oxygenation status of blood sent to the brain?
- a) Left radial
  - b) Left femoral
  - c) Right radial
  - d) Right femoral

98. You are using a 7 mm arterial cannula and your surgeon wants to know what that is in French sizing. What do you tell them?

- a) 14 Fr
- b) 18 Fr
- c) 21 Fr
- d) 24 Fr
- e) 25 Fr

99. What factor will determine the ability or lack of ability for a heart to withstand periods of ischemia and injury?

- e. Level of maturity
- f. Rhythm of the heart
- g. Vascularization of the heart
- h. Temperature of the heart

100. What type of case would Gott shunt be typical to use in?

- e. OPCAB
- f. Descending thoracic aneurysms
- g. Lead extractions
- h. Coronary artery ruptures

ANSWERS:

1. D, C, A, D, D, D, D, A, B, B, C, C, D, C, B, E, C, B, C, B, D, C, C, A, D  
 26. B, A, A, D, C, A, E, A, C, C, C, A, B, C, D, C, A, D, A, C, B, H, E, D, B  
 51. A, A, F, A, C, A, B, B, C, B, C, C, A, C, C, B, E, D, A, D, D, B, D, D, B  
 76. E, B, B, D, A, C, A, C, A, A, A, A, E, B, C, B, D, B, A, C, A, D, C, C, A, B.

**PRACTICE EXAM 2 – 100 QUESTIONS AND ANSWERS**

1. Protamine is an \_\_\_\_\_ protein that is \_\_\_\_\_ charged.
  - a) Acidic, negatively
  - b) Acidic, positively
  - c) Alkaline, negatively
  - d) Alkaline, positively
  
2. The second heart sound is caused by
  - a) The closure of the aortic and pulmonary valves during ventricular diastole
  - b) The opening of the aortic and pulmonary valves during ventricular systole
  - c) The closure of the mitral and tricuspid valves during ventricular systole
  - d) The opening of the mitral and tricuspid valves during ventricular diastole
  
3. What monitoring device would most likely be used to assess cerebral metabolic function?
  - a) Somatosensory evoked potentials
  - b) Bispectral index
  - c) Electroencephalography
  - d) Near-infrared spectroscopy
  - e) Motor evoked potentials
  
4. At the end of a re-do CABG x 4, you hear your surgeon ask the anesthesiologist for DDAVP. Which of the following is true about this drug?
  - a) Exerts its effects by increasing the release of Factor VIII and vWF
  - b) Is a potent dilator of the coronary arteries
  - c) Causes an increase in diuresis by constricting the afferent arteriole of the kidney
  - d) Contraindicated in patients with diabetes insipidus
  
5. Which of the following cytokines causes fever and acute inflammation?
  - a) IL-1
  - b) IL-2
  - c) IL-3
  - d) IL-4
  - e) TNF-alpha
  
6. Typically, the amount of daily output of water from our bodies, from highest to lowest, is from
  - a) Urine, cutaneous transpiration, expired air, feces, sweat
  - b) Urine, sweat, expired air, feces, cutaneous transpiration
  - c) Cutaneous transpiration, sweat, urine, expired air, feces
  - d) Urine, expired air, sweat, cutaneous transpiration, feces

7. You begin working at a new institution where they employ mild hypothermia every case. What would be an appropriate temperature range for this?

- a)  $< 18\text{ }^{\circ}\text{C}$
- b)  $18 - 23\text{ }^{\circ}\text{C}$
- c)  $30 - 34\text{ }^{\circ}\text{C}$
- d)  $24 - 29\text{ }^{\circ}\text{C}$
- e)  $35 - 36\text{ }^{\circ}\text{C}$

8. Ventricular repolarization is reflected on which part of the EKG?

- a) P wave
- b) QRS complex
- c) T wave
- d) P-R interval
- e) ST segment elevations

9. All the following could be a good option to treat cardiogenic shock, except:

- a) Dopamine
- b) Dobutamine
- c) Catecholamines
- d) Beta Blocker
- e) Intra-aortic balloon pump

10. When sterile instruments are opened in a cardiac theatre, the room is said to be an "open room". What is the accepted time for sterility in an open room, after which everything would need to be torn down?

- a) 30 minutes
- b) 1 hour
- c) 2 hours
- d) 4 hours
- e) 8 hours

11. Which of the following is NOT true regarding cardioplegia delivery for heart transplants?

- a) Only antegrade is used
- b) Terminal warm reperfusion doses of 600 – 800 mL are given
- c) Standard maintenance doses of 400 – 600 mL are given
- d) A standard arresting dose of 1000 mL is given

12. Where in the HIPEC circuit does mucus build-up usually occur?

- a) Heat exchanger
- b) Drainage line
- c) Reinfusion line
- d) Waste collection bag

13. Amino acids can cross a membrane at different rates depending on the amount of ATP available. This describes

- a) Simple diffusion
- b) Facilitated diffusion
- c) Primary active transport
- d) Osmosis

14. What organ is likely compromised in patients with high serum creatinine?

- a) Liver
- b) Adrenal glands
- c) Brain
- d) Gallbladder
- e) Kidneys

15. Which of the following is an advantage of ECMO, and not one of VADs?

- e. Less need for anticoagulation
- f. Greater mobility for patients
- g. Biventricular support
- h. Lower risk of infection

16. An inherited blood disorder characterized by decreased hemoglobin production is called what?

- a) Elliptocytosis
- b) Sickle cell anemia
- c) Thalassemia
- d) Spherocytosis
- e) Stomatocytosis

17. Non-pulsatile perfusion increases the production of \_\_\_\_\_ hormone levels which increases vasopressin production, shutting off distal capillary beds.

- a) Angiotensin II
- b) Serotonin
- c) Cortisol
- d) Thyroid
- e) Adrenaline

18. When the PaO<sub>2</sub> is decreased despite normal O<sub>2</sub> carrying capacity, such as high-altitude situations, it causes

- a) Hypoxic hypoxia
- b) Anemic hypoxia
- c) Circulatory hypoxia
- d) Histotoxic hypoxia

19. Abciximab inhibits platelet function by what mechanism of action?

- a) Cyclooxygenase inhibition
- b) ADP receptor blocking

- c) GP IIb/IIIa receptor blocking
20. Myeloid stem cells make all of the following except
- Erythrocytes
  - Platelets
  - Lymphocytes
  - Neutrophils
  - Basophils
  - Eosinophils
21. Which venous site is the most common site for the CVP line?
- Right Subclavian vein
  - Right external jugular vein
  - Left internal jugular vein
  - Right internal jugular vein
22. Myelin
- Increases speed of action potential propagation
  - Increases the rate of neuron firing
  - Increases the release of neurotransmitter
  - Slows the rate of neurotransmitter release
  - Slows the speed of action potential propagation
23. The amount of air that remains in the lungs after complete expiration is known as what?
- Expiratory reserve volume
  - Residual volume
  - Tidal volume
  - Functional residual capacity
  - Vital capacity
24. Which of the following contributes to the hyperpolarized arrest in cardioplegic solution?
- Adenosine
  - Sodium
  - Calcium
  - Aspartate/glutamate
  - Potassium
25. Blood flow to the gravid uterus is primarily under control by which of the following receptors?
- Muscarinic
  - Alpha
  - Beta
  - Neuromuscular
  - Dopaminergic

26. Which of the following ECMO cannulation sites may require an additional distal perfusion cannula to prevent distal limb ischemia?
- Ascending aorta
  - Femoral artery
  - Axillary artery
27. Which of the following is an important role of albumin?
- Maintain colloid osmotic pressure
  - Normal impulse conduction
  - Maintain cardiac rhythm
  - Blood clotting
  - Replacing bicarbonate ions taken up by RBCs
28. Which of the following is considered the most broad-spectrum penicillin antibiotic?
- Penicillin G
  - Nafcillin
  - Amoxicillin
  - Ticarcillin
  - Piperacillin
29. Which of the following cannulation strategies describes VA ECMO?
- Dual lumen cannula via RIJ draining from IVC and SVC and reinfusing in the RA
  - Drainage from the femoral vein, reinfusion in the femoral artery
  - Drainage from the IVC via the femoral vein, reinfusion in the SVC via RIJ
30. What is the normal flow rate for AV ECMO?
- 70 – 80% of CO
  - 10 – 20% of CO
  - 30 – 80% of CO
  - 20 – 30% of CO
  - 30 – 90% of CO
31. A patient has a pH of 7.26 pCO<sub>2</sub> of 50 and HCO<sub>3</sub> of 26. This patient most likely has:
- Respiratory acidosis
  - Respiratory alkalosis
  - Metabolic acidosis
  - Metabolic alkalosis
32. Which of the following is most likely caused by vasospasm, and occurs at rest or awakens patients from sleep?
- Typical angina pectoris
  - Silent myocardial ischemia
  - Unstable angina
  - Prinzmetal's angina

- e) Non-ST-segment myocardial ischemia
33. Which of the following drugs would be given before deep hypothermic circulatory arrest to stabilize cell membranes, scavenge oxygen free radicals, and minimize cerebral edema?
- a) Bicarbonate
  - b) Brevital
  - c) Mannitol
  - d) THAM
  - e) Methylprednisone
34. Which of the following is characterized by a large left atrial to left ventricular gradient during ventricular diastole?
- a) Mitral stenosis
  - b) Mitral regurgitation
  - c) Aortic stenosis
  - d) Aortic regurgitation
35. A non-modifiable factor that would affect a child's neurological development would be:
- e. Acidosis
  - f. Hypotension
  - g. Socioeconomical factors
  - h. History of cardiac arrest
36. Which of the following is the treatment of choice for disseminated cancers?
- a. Surgery
  - b. Radiation therapy
  - c. Chemotherapy
  - d. Hormone antagonist
37. Which of the following cardioplegia constituents antagonizes calcium by acting as a natural calcium channel blocker?
- a) Potassium
  - b) Magnesium
  - c) Lidocaine
  - d) Sodium
  - e) Adenosine
38. A patient with A+ blood can receive which of the following blood types?
- a) AB-
  - b) O-
  - c) B+
  - d) AB-
  - e) B-
39. 1000 units of ATIII will increase ATIII level by how much?

- a) ~10%
  - b) ~30%
  - c) ~50%
  - d) ~70%
  - e) ~90%
40. After sending a bolus of air to the patient you begin going through your air embolism protocol. One of the techniques you want to employ is “off-gassing”, which of the following describes the basic principle and goal of this technique?
- a) Lowering  $FiO_2$  to avoid oxygen toxicity
  - b) Increasing sweep rate to lower  $pN_2$  levels
  - c) Adding  $CO_2$  to the circuit to increase  $PCO_2$  levels
  - d) Using a 100%  $FiO_2$  to reduce  $PaN_2$  levels
  - e) Reducing the sweep rate to increase  $pCO_2$  levels
41. Which of the following helps break down the toxic metabolite of acetaminophen, and is depleted by alcohol?
- a. Cytochrome p450
  - b. Glutathione
  - c. Glutamate
  - d. Aspartate
  - e. Tyrosine
42. What is the normal range of albumin?
- a) 3.5 – 5.0 g/dL
  - b) 4.0 – 6.3 g/dL
  - c) 1.7 – 2.3 g/dL
  - d) 3.0 – 6.5 g/dL
  - e) 1. – 8.0 g/dL
43. Hyperventilating the patient and/or having your gas sweep rate on too high will most likely cause which of the following acid – base status changes?
- a) Metabolic acidosis
  - b) Respiratory alkalosis
  - c) No change
  - d) Metabolic alkalosis
  - e) Respiratory acidosis
44. When one lung is allowed venous return to flow through it during CPB, which of the following occurs?
- a) Perfused lung has a relative decrease in damage
  - b) Perfused lung has a relative increase in damage
  - c) Perfused lung has the same level of insult as lung not perfused
45. Which of the following statement(s) are false about the sinus venosus?
- r. It is the cavity the vena cava drain into during early fetal circulation

- b. The left horn and sinus venosus become the RA
  - f. It contributes to the conduction system and development of the SA and AV nodes
  - g. The left and right horns are connected to umbilical, vitelline, anterior and common cardinal veins
  - h. A and D
46. What is the normal range for systemic vascular resistance (SVR)?
- a) 20 – 130 dynes\*sec/cm<sup>5</sup>
  - b) 30 – 120 dynes\*sec/cm<sup>5</sup>
  - c) 700 – 1600 dynes\*sec/cm<sup>5</sup>
  - d) 600 – 1700 dynes\*sec/cm<sup>5</sup>
  - e) 1800 – 2200 dynes\*sec/cm<sup>5</sup>
47. Which form of cold agglutination involves complement activation?
- a) Primary
  - b) Secondary
48. In the skeletal muscle excitation-contraction processes, what must occur before T tubules are depolarized?
- a) The sarcolemma membrane is depolarized
  - b) ATP splitting occurs
  - c) Sarcoplasmic reticulum releases calcium
  - d) Calcium binds to troponin C
  - e) Actin and Myosin bind
49. In 1953, who completed the first successful operation using a heart-lung machine with both a pump and an oxygenator?
- a) Bigelow
  - b) Dodrill
  - c) Lillehei
  - d) Gibbon
  - e) Sones
50. Which of the following cannulation strategies would be appropriate for a mitral valve repair/replacement?
- a) Bicaval venous cannulation
  - b) Dual-stage venous cannulation
  - c) Basket sucker in LA
  - d) b + c
  - e) a/b + c
51. At what thermal gradient will gas come out of the solution?
- a)  $\geq 15^{\circ}\text{C}$
  - b)  $\geq 13^{\circ}\text{C}$
  - c)  $\geq 17^{\circ}\text{C}$

- d)  $\geq 11^{\circ}\text{C}$
  - e)  $\geq 19^{\circ}\text{C}$
52. A patient receives a heart transplant that is ultimately rejected by his body due to a T lymphocytes reaction. This is most likely which Type of hypersensitivity response?
- a) Type I
  - b) Type II
  - c) Type III
  - d) Type IV
53. Which of the following best describes the Q10 effect?
- a) The change in metabolic rate per  $10^{\circ}\text{F}$  change, typically  $\sim 30\%$
  - b) The change in metabolic rate per  $10^{\circ}\text{C}$  change, typically  $\sim 50\%$
  - c) The change in metabolic rate per  $50^{\circ}\text{C}$  change, typically  $\sim 10\%$
  - d) The change in metabolic rate per  $10^{\circ}\text{F}$  change, typically  $\sim 50\%$
  - e) The change in metabolic rate per  $10^{\circ}\text{C}$  change, typically  $\sim 70\%$
54. The first pump oxygenator was successfully created by \_\_\_\_\_ in 1885:
- a) Forssmann
  - b) von Frey & Gruber
  - c) Gibbon
  - d) DeWall
  - e) Lewis & Taufic
55. With neonates, the main goal of palliative procedures is to control \_\_\_\_\_ blood flow to allow for growth but without excessive blood flow to the \_\_\_\_\_ circulation and impaired \_\_\_\_\_ perfusion and volume overload to the \_\_\_\_\_ ventricle.
- e. Pulmonary, pulmonary, systemic, systemic
  - f. Pulmonary, systemic, systemic, pulmonary
  - g. Systemic, systemic, pulmonary, pulmonary
  - h. Systemic, pulmonary, pulmonary, systemic
56. When comparing cardiogenic, hypovolemic, and septic shock, which of the following statements is false?
- a) All result in a low urine output
  - b) All result in a cool skin temperature
  - c) All result in low blood pressure
  - d) Septic shock is the only one that will result in low systemic vascular resistance
57. Which of the following receptors is responsible for dilation of the pupil?
- a. Alpha 1
  - b. Alpha 2
  - c. Beta 1
  - d. Beta 2

- e. Muscarinic 2
- f. Muscarinic 3
- g. Nicotinic (n)
- h. Nicotinic (m)

58. Which type of VSD is the most common?

- e. I
- f. II
- g. III
- h. IV

59. What is the normal time range for aPTT?

- a) 2 – 3 seconds
- b) 10 – 15 seconds
- c) 11 – 13 seconds
- d) 30 – 40 seconds
- e) 35 – 60 seconds

60. Which of the following is NOT a component of Virchow's Triad?

- a) Endothelial injury
- b) Abnormal blood flow
- c) Hypercoagulability
- d) Immobility

61. Which of the following is an indication of irreversible cell injury?

- a) Blebs
- b) Swelling
- c) Karyorrhexis
- d) Cellular accumulations
- e) Nuclear chromatin clumping

62. What is the normal range for white blood cell count?

- a) 1000 – 12000/ $\mu$ L
- b) 4500 – 11000/ $\mu$ L
- c)  $1 \times 12^4$ / $\mu$ L
- d)  $4.5 \times 11^4$ / $\mu$ L
- e) None of the above

63. Which of the following receptors is responsible for constriction of the bronchi?

- a. Alpha 1
- b. Alpha 2
- c. Beta 1
- d. Beta 2
- e. M 1

- f. M 2
- g. M 3
- h. Nicotinic (n)
- i. Nicotinic (m)

64. In the 3-letter NBG code (North American Society of Pacing and Electrophysiology and the British Pacing and Electrophysiology Group), what does the first letter indicate?

- a) Chamber paced
- b) Sensed response
- c) Chamber sensed

65. Which of the following is a correct calculation? (Q=flow, CO = Cardiac Output, SV=Stroke Volume, HR=Heart Rate, SVR=Systemic Vascular Resistance, MAP=Mean arterial Pressure, TPR=Total Peripheral Resistance)

- a)  $Q = CO \times SV$
- b)  $CO = SV \times HR$
- c)  $BP = HR \times SVR$
- d)  $MAP = CO \times HR$
- e)  $MAP = TPR \times SV$

66. The primary mechanism of action of most penicillins is to

- a. Inhibit DNA gyrase
- b. Inhibit RNA polymerase
- c. Disrupt the 30S subunit
- d. Disrupt the 50S subunit
- e. Inhibit protein synthesis
- f. Block cell wall synthesis

67. Which of the following cannulation strategies would be appropriate for an aortic valve replacement?

- a) Bicaval venous cannulation
- b) Dual-stage venous cannulation
- c) LV vent through the aortic valve
- d) b + c
- e) a/b + c

68. Which immunoglobulin is most likely secreted in milk and saliva?

- a) IgA
- b) IgD
- c) IgM
- d) IgE
- e) IgG

69. What are the beats per minute (BPM) usually set at?

- a) 40
  - b) 120
  - c) 100
  - d) 60
  - e) 20
70. What is the normal range of ionized calcium?
- a) 4.2 – 5.9 mg/dL
  - b) 2.5 – 3.2 mEq/L
  - c) 4.5 – 5.6 mg/dL
  - d) 1.2 – 2.3 mmol/L
  - e) 1.1 – 1.3 mmol/L
71. Your patient has a p-wave rate of 90 and a v-wave rate of 80 with no synchrony between the atria and ventricles. Which of the following modes is your patient in?
- a) DDI
  - b) DDD
72. Obtaining immunity through immunoglobins in breast milk as an infant is an example of
- a) Natural active acquired immunity
  - b) Artificial active acquired immunity
  - c) Natural passive acquired immunity
  - d) Artificial passive acquired immunity
73. Which of the following would be within the normal range (in seconds) for prothrombin time (PT)?
- a) 1.0
  - b) 6
  - c) 13
  - d) 31
74. Mother-fetus Rh factor incompatibility problems can happen if the mom is \_\_\_\_ and her fetus is \_\_\_\_.
- a) Rh +; Rh +
  - b) Rh +; Rh –
  - c) Rh –; Rh +
  - d) Rh –; Rh –
  - e) b + c
75. Which of the following antibiotics is most commonly used to treat pseudomonas aeruginosa?
- a. Piperacillin
  - b. Amoxicillin
  - c. Penicillin G

- d. Vancomycin
- e. Aztreonam

76. What is the primary mechanism of action of heparin?

- a. Increases the plasma level of factor IX
- b. Inhibits thrombin
- c. Inhibits synthesis of prothrombin and coagulation factors VII, IX, and X
- d. Inhibits platelet aggregation in vitro
- e. Activation of plasminogen
- f. Binding of calcium ion cofactor in the coagulation cascade.

77. A patient with an extremely rare blood type is going to have surgery in a few months. What would be the best preoperative blood salvaging technique to ensure you have available blood products to give the patient?

- a) Autologous blood donation
- b) Cell-saver (autotransfusion)
- c) Pump suction
- d) Ultrafiltration
- e) Autologous priming

78. A pressure waveform shows diastolic augmentation encroaching onto a systolic beat and a dicrotic notch is not present. What is happening?

- a) Early deflation
- b) Late deflation
- c) Early inflation
- d) Late inflation

79. Which structure change is anatomically correct?

- e. Ductus arteriosus → Ligamentum venosum
- f. Umbilical vein → Ligamentum teres hepatis
- g. Umbilical arteries (proximal) → medial umbilical ligaments
- h. Ductus venosus → Ligamentum arteriosum

80. Which of the following is going to occur if antegrade cardioplegia is delivered with Bicaval venous cannulation with tapes?

- a) RA distention
- b) Maldistribution of cardioplegia
- c) LV distension
- d) LA distension
- e) RV distension

81. You see white flakes in your pump head raceway. What kind of tubing is this?

- a) Silastic
- b) Super Tygon
- c) Polyvinyl chloride
- d) Polyurethane

- e) None of the above
82. All of the following are vitamin K-dependent coagulation factors, except
- a. II
  - b. VII
  - c. IX
  - d. X
  - e. XII
83. Which of the following would be a correct order of excitation-contraction in skeletal muscle?
- a) Increased intracellular calcium concentration, action potential, cross-bridge formation
  - b) Action potential, T tubule depolarization, calcium is released from the sarcoplasmic reticulum
  - c) Splitting of ATP, binding of calcium to troponin C, action potential
  - d) Splitting of ATP, release of calcium from sarcoplasmic reticulum, depolarization of T tubules
84. Cytotoxic drugs include all of the following categories, except:
- a. Alkylating agents
  - b. Antimetabolites
  - c. Mitotic inhibitors
  - d. Topoisomerase inhibitors
  - e. Hormone antagonists
85. Which pregnancy trimester poses the lowest risk of heart surgery?
- a) 1<sup>st</sup> trimester
  - b) 2<sup>nd</sup> trimester
  - c) 3<sup>rd</sup> trimester
86. Which of the following is a diuretic that can be used for both prophylaxis of renal failure and the reduction of intracranial pressure?
- a. Acetazolamide
  - b. Furosemide
  - c. Hydrochlorothiazide
  - d. Spironolactone
  - e. Mannitol
87. Which of the following drugs used for HIPEC works by binding to guanine residues, preventing replication and triggering apoptosis?
- a) Mitomycin C
  - b) Doxorubicin

- c) Cisplatin
88. Ischemic neuronal cells fail to maintain the ability to run ionic pumps and thus undergo membrane depolarization leading to an increase in intracellular calcium and release of neuroexcitatory amines such as \_\_\_\_\_.
- a) Aspartate
  - b) Glutamine
  - c) Glutamate
  - d) Arginine
  - e) Gluconate
89. Beta cells from the pancreas secrete which of the following?
- a) Insulin
  - b) Glucagon
  - c) Glucose
90. A patient has a sample taken of his arterial blood. His hemoglobin content of 15 g/dL. His SaO<sub>2</sub> is 98%, and his PaO<sub>2</sub> is 99 mmHg. What is his approximate arterial blood oxygen content?
- a. 20 mL/dL
  - b. 0.20 mg/dL
  - c. 25 mL/dL
  - d. 20 mg/dL
  - e. 2 mg/dL
91. What is the initial dosage range for heparin for CPB?
- a) 300 – 400 units/kg
  - b) 100 – 200 units/kg
  - c) 150 – 250 units/kg
  - d) 350 – 450 units/kg
  - e) 500 – 600 units/kg
92. All of the following decrease extracellular potassium, except
- a) Insulin
  - b) Aldosterone
  - c) Beta adrenergic stimulation
  - d) Alkalosis
  - e) Cell lysis
93. Which of the following is going to occur if antegrade cardioplegia is delivered with Bicaval venous cannulation with tapes?
- a) RA distention
  - b) Maldistribution of cardioplegia
  - c) LV distension
  - d) LA distension
  - e) RV distension

94. Pulmonary veins

- a) Leave the lung as five pulmonary veins
- b) Enter the right atrium
- c) Collect deoxygenated blood from the respiratory part of the lung
- d) Supply oxygenated blood to the non-respiratory conducting tissues of the lungs

95. Which of the following diuretics binds to an aldosterone receptor?

- a. Propranolol
- b. Amiloride
- c. Furosemide
- d. Spironolactone
- e. Hydrochlorothiazide

96. Blood is refrigerated to slow down metabolic activity and inhibit the growth of bacteria. What temperature is blood stored at?

- a) 8 – 10 °C
- b) 10 – 15 °C
- c) 20 – 24 °C
- d) 1 – 6 °C
- e) 15 – 18 °C

97. What is the target cardiac index (CI) for adults?

- a) 1.8 – 3.0 L/min/m<sup>2</sup>
- b) 2.0 – 2.5 L/min/m<sup>2</sup>
- c) 2.0 – 3.0 L/min/m<sup>2</sup>
- d) 2.2 – 2.8 L/min/m<sup>2</sup>
- e) 2.8 – 3.2 L/min/m<sup>2</sup>

98. All the following can be common characteristic lesions of rheumatic heart disease, except

- a) Mitral valve stenosis
- b) Mitral valve regurgitation
- c) Aortic valve stenosis
- d) Pulmonary valve stenosis
- e) Infective endocarditis

99. A middle-aged man suffering from an acute MI is treated with alteplase. What is the primary mechanism of action of this drug?

- a. Inhibits platelet thromboxane production
- b. Antagonizes ADP receptors
- c. Glycoprotein IIb/IIIa antagonist
- d. Inhibits the synthesis of vitamin K-dependent coagulation factors
- e. Activation of plasminogen from plasmin

100. Which of the following drugs causes lysis of antigen activated lymphocytes and blocks production of IL-1?

- a. Cyclosporine
- b. Daclizumab
- c. Methotrexate
- d. Glucocorticoids

ANSWERS:

1. D, A, D, A, A, A, C, C, D, C, D, A, C, E, C, C, A, A, C, C, D, A, B, A, B  
26. B, A, C, B, D, A, D, E, A, C, C, B, B, B, D, B, A, B, B, B, C, B, A, D, D  
51. A, D, B, B, A, B, A, B, D, D, C, B, G, C, B, F, E, A, D, E, A, C, C, C, A  
76. B, A, C, B, A, A, E, B, E, B, E, C, C, A, A, A, E, A, A, D, D, B, D, E, D

**PRACTICE EXAM 3 – 100 QUESTIONS AND ANSWERS**

1. How is D-Transposition of the great arteries is different than C-transposition?
  - e. D-Transposition has great vessels and ventricles transposed, while C-transposition does not
  - f. D-Transposition only has only one great vessel and ventricle transposed, while C-transposition has both
  - g. D-Transposition has great vessels transposed, while C-transposition has both ventricles and great vessel transposed
  - h. D-Transposition has only ventricles transposed, while C-transposition has great vessels transposed
2. During descending aortic surgery, you note the following changes: ↓ proximal arterial pressure, ↑ distal arterial pressure, ↓ pulmonary wedge pressure. What should your treatment be?
  - a) Decrease pump flow; may need volume
  - b) Increase pump flow; inotrope
  - c) Decrease pump flow; inotrope; diuretic
  - d) Volume; increase pump flow
  - e) Volume; vasodilator
3. Tidal volume plus inspiratory reserve volume is known as what?
  - a) Inspiratory capacity
  - b) Total lung capacity
  - c) Vital capacity
  - d) Functional residual capacity
4. Which of the following inhalational anesthetics is NOT able to be used during CPB?
  - e. Isoflurane
  - f. Nitrous oxide
  - g. Sevoflurane
  - h. Desflurane
5. How soon before surgery should Plavix be discontinued before surgery?
  - a) 1 – 2 days
  - b) 5 – 7 days
  - c) 2 – 4 days
  - d) 8 – 9 days
  - e) 11 – 13 days
6. Which of the following is NOT true of magnesium?
  - a) Cofactor in the clotting cascade
  - b) Positive inotrope
  - c) Anti-arrhythmic
  - d) Normal range = 1.7 – 2.1 mg/dL
  - e) Natural calcium channel blocker

7. How much blood flow do the coronaries receive and when?
- ~125 mL/min during systole
  - ~125 mL/min during diastole
  - ~225 mL/min during systole
  - ~225 mL/min during diastole
  - ~400 mL/min during systole
8. Paralysis or atonia of blood vessels that leads to a failure of cerebral saturations to respond to re-warming and increased flow after deep hypothermic circulatory arrest (DHCA) is known as which of the following?
- Choreoathetosis
  - No-reflow phenomenon
  - Edema
  - Vasoparesis
  - Seizure
9. Antifibrinolytic drugs (e.g., aminocaproic acid) may be used as an antidote for which of the following drugs?
- Enoxaparin
  - Enalapril
  - Recombinant tissue plasminogen activator (rtPA)
  - Clopidogrel
  - Losartan
10. Which of the following is the drug of choice for severe hypoglycemia?
- IV insulin
  - IV glucagon
  - Oral meglitinides
  - Subcutaneous sulfonylureas
  - Sublingual rosiglitazone
11. Which of the following is considered an advantage of hemodilution?
- Decreased blood viscosity
  - Decreased blood pressure
  - Dilution of plasma proteins
  - Movement of fluid out of the vascular space into the interstitial and extracellular space
  - None of the above
12. What would be an appropriate flow rate for ostial delivery of cardioplegia?
- 90 -110 mL/min
  - 150 – 200 mL/min
  - 300 – 400 mL/min
  - 250 – 300 mL/min
  - 10 – 40 mL/min
13. The parasympathetic nervous system mostly originates from

- a) Thoracic vertebrae
- b) Lumbar vertebrae
- c) T1 – L2
- d) Sacral Vertebrae
- e) Brainstem and S1-S4

14. Which of the following ions is the most prevalent extracellular electrolyte that plays an important role in maintaining fluid balance?

- a) Potassium
- b) Chloride
- c) Calcium
- d) Sodium
- e) Magnesium

15. Cells are put into a hypotonic solution. Which of the following will occur?

- a. Cells will swell
- b. Cells will shrink
- c. Cells will shift from one side of the solution to another
- d. The cells and its organelles will remain the same size and location
- e. Organelles inside the cells will all move to one side of the cell

16. Which of the following can greatly decrease the rate of firing through the AV node, slowing the heart rate?

- a) Sympathetic nerves
- b) Norepinephrine
- c) Epinephrine
- d) Vagus nerve
- e) Beta adrenergic activity

17. The right internal mammary artery originates from the

- a) Internal thoracic artery
- b) Thoracic aorta
- c) Aortic arch
- d) Right subclavian artery
- e) Intercostal artery

18. How does hemodilution affect cerebral blood flow (CBF)?

- a) Increases CBF
- b) Decreases CBF
- c) No change

19. What heart structure does the Impella partially or fully bypass?

- e. Right ventricle

- f. Aorta
  - g. Left ventricle
  - h. Pulmonary artery
20. Which of the following tests is NOT considered a basic test in the assessment of cardiac-related diseases?
- a) Chest x-ray
  - b) Electrocardiogram (ECG/EKG)
  - c) Transthoracic Echocardiography
  - d) Cardiac Catheterization
  - e) c + d
21. Cold agglutinins: the temperature threshold below which antibodies become activated is known as which of the following:
- a) Thermal amplitude
  - b) Titer
22. Which of the following is NOT true regarding perfusion management for a diabetic patient?
- a) Insulin infusions are often required, especially for Type 2 diabetic patients
  - b) Cerebral autoregulation is often impaired, requiring higher perfusion pressures
  - c) Nitroprusside administration may be done to improve cerebral blood flow
  - d) Cerebral vessels have a higher sensitivity to changes in pCO<sub>2</sub>
  - e) Mannitol should be given for oxygen-free radical management
23. When treating methemoglobinemia, your patient fails to respond to methylene blue. Which of the following would be appropriate to administer next?
- a) Vitamin A
  - b) Vitamin C
  - c) Vitamin D
  - d) Vitamin E
  - e) Vitamin K
24. Which of the following is NOT a risk factor for a protamine reaction?
- a) Fish allergies
  - b) Bolus administration
  - c) Edematous patients
  - d) Redo cardiovascular surgery
  - e) Vasectomized males
25. During descending aortic surgery, you note the following changes: ↑ proximal arterial pressure, ↓ distal arterial pressure, ↑ pulmonary wedge pressure. What should your treatment be?
- a) Increase pump flow
  - b) Decrease pump flow; inotrope; diuretic
  - c) Increase pump flow; inotrope
  - d) Volume; increase pump flow
  - e) Volume; vasodilator

26. Which of the following is more indicative of chronic inflammation rather than acute inflammation?
- a) Pus formation
  - b) Granuloma
  - c) Ulcer
  - d) Fibrin
  - e) Clear exudate
27. What is the loading dose of heparin for veno-venous bypass?
- a) 200 units/kg
  - b) 300 units/kg
  - c) 50 units/kg
  - d) 400 units/kg
  - e) 0 units/kg
28. What is the normal range for activated partial thromboplastin time (aPTT)?
- a) 20 – 25 seconds
  - b) 35 – 45 seconds
  - c) 10 – 15 seconds
  - d) 15 – 30 seconds
  - e) 45 – 55 seconds
29. The amount of air inspired and expired in a normal breath is called what?
- a) Inspiratory capacity
  - b) Vital capacity
  - c) Tidal volume
  - d) Expiratory reserve volume
  - e) Residual volume
30. Which of the following is true about Insulin?
- a. Commonly prescribed for Type II DM
  - b. Given orally for diabetic ketoacidosis
  - c. Can treat hypocalcemia
  - d. Can treat hyperkalemia
  - e. Can treat hypokalemia
31. What drug is given post cross-clamp as an oxygen-free radical scavenger?
- a) Lidocaine
  - b) Magnesium
  - c) Mannitol
  - d) Calcium
  - e) Bicarbonate
32. Which of the following is perfused by branches of the left anterior descending (LAD)?
- a) Posterior - lateral wall of the LV
  - b) Right anterior wall of the RV

- c) Posterior inferior aspect of the LV
  - d) Lateral wall of the RV
  - e) Anterior interventricular septum
33. Unlike in adults, what major complication that is more frequently posed when considering cannulation sites for a pediatric patient?
- e. If the patient's chest is open
  - f. The number of times the patient has been cannulated
  - g. The patient's anatomy
  - h. The way in which the patient is being monitored
34. Which of the following factors would decrease calcium excretion?
- a) Decreased PTH
  - b) Increased Blood pressure
  - c) Increased extracellular fluid volume
  - d) Metabolic acidosis
  - e) Increased blood pressure
35. Which of the following platelet counts is the threshold for thrombocytopenia?
- a)  $> 450,000/\mu\text{L}$
  - b)  $< 10,000/\mu\text{L}$
  - c)  $< 50,000/\mu\text{L}$
  - d)  $> 350,000/\mu\text{L}$
  - e)  $< 100,000/\mu\text{L}$
36. Which of the following types of shock is most likely caused by heart failure
- a) Cardiogenic
  - b) Hypovolemic
  - c) Obstructive
  - d) Anaphylactic
  - e) Neurogenic
  - f) Septic
37. Which of the following cross-clamps is designed for minimally invasive procedures, with cardioplegia delivery and vent capabilities?
- a) Cosgrove flex clamp
  - b) DeBakey cross-clamp
  - c) Morris cross-clamp
  - d) Fogarty Hydragrip cross-clamp
  - e) Endoaortic cross-clamp
38. A patient is given the wrong type of blood and has an ABO incompatibility transfusion reaction. Membrane attack complexes in her body cause red blood cell lysis and death. This is likely which type of hypersensitivity reaction?

- a) Type I
  - b) Type II
  - c) Type III
  - d) Type IV
39. A protein-rich liquid that can separate out when blood coagulates is called
- a. Plasma
  - b. Gel
  - c. Platelets
  - d. Hematocrit
  - e. Serum
40. \_\_\_\_\_ is due to obstruction within the urinary collecting system.
- a) Renal cell carcinoma
  - b) Prerenal failure
  - c) Intrarenal failure
  - d) Postrenal failure
41. All of the following would be appropriate actions to take for an accidental hypothermia case EXCEPT what?
- a) Stimulate urine output via mannitol or furosemide
  - b) Match priming solution temperature with the patient temperature
  - c) Maintain high blood pressure with phenylephrine
  - d) Include a hemoconcentrator to assist in volume control
  - e) Put half a loading dose of heparin into the pump
42. What is the most common pulmonary complication in cardiac surgery?
- a) Bronchospasm
  - b) Pulmonary edema
  - c) Acute respiratory distress syndrome
  - d) Atelectasis
  - e) Pump lung
43. The umbilical vein forms into which of the following after birth?
- a) Ligamentum teres hepatis
  - b) Medial umbilical ligament
  - c) Ligamentum arteriosum
  - d) Ligamentum venosum
44. If the only acid/base mechanism operating is ventilation, which of the following statements would most likely be true?
- a) As the rate of alveolar ventilation increases, pH in body tissues increases
  - b) As the rate of alveolar ventilation increases, pH in body tissues decreases
  - c) As the rate of alveolar ventilation decreases, pH in the body increases

- d) As the rate of alveolar ventilation decreases, pH in the body remains constant
45. The air at sea level is 21% O<sub>2</sub>. If the atmospheric pressure is 760 mmHg at sea level, what would the partial pressure of O<sub>2</sub> in the air at sea level be?
- a. 36 mmHg
  - b. 160 mmHg
  - c. 16000 mmHg
  - d. 360 mmHg
  - e. 190 mmHg
46. You calculate your oxygen extraction to be 20% and you want to increase it. Which of the following would NOT be an appropriate option to do so?
- a) Hypercarbia
  - b) Rewarm the patient
  - c) Hemoconcentrate
  - d) Administer RBCs
  - e) Administer sodium bicarbonate
47. In the 3-letter NBG code, what does the second letter indicate?
- a) Sensed response
  - b) Chamber paced
  - c) Chamber sensed
48. The most common congenital heart disease in children is
- a) Atrioventricular septal defect
  - b) Ventricular septal defect
  - c) Patent ductus arteriosus
  - d) Tetralogy of Fallot
  - e) Aortic stenosis
49. A 62-year-old male with a history of hyperlipidemia and hypertension comes to the clinic for a checkup. The patient states that about 10 days ago he was working outside and experienced chest pain that radiated to his jaw and shortness of breath. The patient stated that these symptoms were relieved upon resting and has not experienced the symptoms since. Which of the following lab results would be expected?
- a) Elevated myoglobin, elevated troponin-I, and elevated CK-MB
  - b) Normal myoglobin, elevated troponin-I, and normal CK-MB
  - c) Elevated myoglobin, normal troponin-I, and normal CK-MB
  - d) Normal myoglobin, normal troponin-I, and elevated CK-MB
  - e) Normal myoglobin, normal troponin-I, and normal CK-MB
50. The major endogenous opioid receptor is
- a. Kappa
  - b. Alpha

- c. Delta
- d. Mu

51. Which of the following veins typically will drain into the left brachiocephalic vein?

- a) Left Azygos
- b) Left Hemiazygos
- c) Left superior intercostal
- d) Left Internal thoracic

52. Which of the following is a more typical consequence of left heart failure than right heart failure?

- a) Chronic congestion of the lungs
- b) Chronic congestion of the spleen
- c) Venous congestion
- d) Peripheral edema
- e) Chronic congestion of the liver

53. Which of the following reasons best explain why neonates are at a greater risk of bleeding?

- e. Immature clotting system
- f. Lower levels of ATIII
- g. Reduced platelet activity
- h. All the above

54. How is heparin bound in Cortiva tubing?

- a) Van der Waals forces
- b) Covalent bonds
- c) Hydrogen bonds
- d) Ionic bonds
- e) Polar bonds

55. Calculate the anion gap if the Sodium is 142, Bicarb is 24, Potassium is 5, CO<sub>2</sub> is 40, and Chloride is 106.

- a) 10
- b) 11
- c) 12
- d) 15
- e) 16

56. Erythroblastosis fetalis in a neonate may be treated by which of the following ways?

- a) Hemoconcentration and plasmapheresis
- b) Total blood exchange transfusion
- c) Plasmapheresis
- d) Leukocyte depleting filter
- e) Rhogam

57. You are working with your manufacturer to reduce the prime volume of your circuit. You remove one foot of 3/8'' tubing and a half foot of 1/2'' tubing. Roughly how much was prime volume reduced?
- 21 mL
  - 27 mL
  - 32 mL
  - 41 mL
  - 44 mL
58. Which form of heparin-induced thrombocytopenia (HIT) is immunologically induced?
- HIT Type I
  - HIT Type II
59. What level of cardiac support does VV ECMO provide?
- Full cardiac support
  - Heavy cardiac support
  - Moderate cardiac support
  - Low cardiac support
  - No cardiac support
60. During a depolarized arrest, which ion channel plays a pivotal role in preventing subsequent depolarization events from occurring?
- Calcium channels
  - Magnesium channels
  - Potassium channels
  - Chloride channels
  - Sodium channels
61. What is the treatment for a low  $\alpha$  angle on a thromboelastograph (TEG)?
- Cryoprecipitate
  - Tranexamic Acid (TXA)
  - Platelets
  - Plasma
  - None of the above
62. How many units of heparin per mL of FFP is standard?
- 10 units/mL
  - 4 units/mL
  - 20 units/mL
  - 1 unit/mL
  - 5 units/mL
  - 8 units/mL
63. How much heparin is in a liter of saline used for cell saver salvage?
- 10,000 units/L
  - 20,000 units/L
  - 30,000 units/L
  - 40,000 units/L

- e) 50,000 units/L
64. Which of the following conditions is most likely to cause left ventricular hypertrophy?
- a) Constriction of the pulmonary trunk
  - b) A stenotic left atrioventricular valve
  - c) An abnormally large right atrioventricular valve
  - d) Excessive aortic calcification
65. Which of the following is the most common gastrointestinal (GI) complication from CPB?
- a) Endotoxemia
  - b) Splenic infarction
  - c) GI bleeding
  - d) Duodenal ulcers
  - e) Diverticulosis
66. What percentage of carbon dioxide transferring out of the blood arrives in the form of  $\text{HCO}_3^-$ ?
- a) 1%
  - b) 5%
  - c) 30%
  - d) 65%
  - e) 99%
67. Transesophageal echocardiography (TEE) may be used to assess which of the following?
- a) Valvular function
  - b) Left and/or right ventricular function
  - c) Intracardiac air
  - d) All the above
  - e) None of the above
68. In 1955, the first disposable bubble oxygenator was reportedly used by who?
- a) DeWall
  - b) Lewis & Taufic
  - c) Kirklin
  - d) Gibbon
  - e) Dodrill
69. What is the traditional loading dose of heparin for bypass?
- a) 250 – 350 U/kg
  - b) 200 – 400 U/kg
  - c) 300 – 400 U/kg
  - d) 50 – 150 U/kg
  - e) 100 – 150 U/kg

70. Which HIPEC technique involves temporarily sealing the abdomen around the cannulas and then agitating the abdomen from the exterior to distribute the lavage?

- a) Coliseum
- b) Closed abdomen

71. All of the following shift the oxygen-hemoglobin dissociation curve to the right, except:

- a. Increased pH
- b. Increased CO<sub>2</sub>
- c. Increased temperature
- d. Increased 2,3 DPG

72. Your surgeon asks you to cool to 18°C and wants to know the safe time for circulatory arrest. What would be an appropriate time to tell them?

- a) 15 minutes
- b) 70 minutes
- c) 10 minutes
- d) 45 minutes
- e) 25 minutes

73. Which of the following complications may happen if you do not come up on flows fast enough for antegrade delivery of cardioplegia?

- a) Myocardial edema
- b) Aortic valve remains open
- c) Coronary dissection
- d) Aortic dissection

74. An antibiotic was administered intravenously to a patient with an infection. It was given in a dose of 5 mg/kg into a 70 kg female. The volume of distribution of the drug is found to be 5 L and the clearance was determined to be 3.5 L/day. What is the approximate half-life of this drug?

- a. 1 hour
- b. 3.5 hours
- c. 7 hours
- d. 24 hours
- e. 3.5 days

75. How does hemodilution affect glomerular filtration rate (GFR)?

- a) Hemodilution reduces GFR by increasing renal edema
- b) Hemodilution increases GFR by increasing blood viscosity
- c) Hemodilution reduces GFR by reducing afterload
- d) Hemodilution increases GFR by reducing blood viscosity
- e) Hemodilution has nominal effects on GFR due to autoregulation

76. Which of the following is most likely to cause an enlarged left atrium, which can result in atrial arrhythmias and mural thrombi?

- a) Mitral stenosis
- b) Mitral regurgitation
- c) Aortic stenosis
- d) Aortic regurgitation

77. Which of the following is true about fondaparinux?

- a. It should not be given to patients with a heparin allergy
- b. It inhibits platelets, and 80% of its clearance is metabolic
- c. Its clearance is by the liver, so it can be used in patients with poor liver function
- d. It is approved for treatment of clots in patients with heparin-induced thrombocytopenia (HIT)
- e. It is not reversible with protamine

78. Which type of diabetes occurs when your body either resists the effects of insulin or does not produce enough insulin to maintain normal glucose levels?

- a) Type 1
- b) Type 2
- c) Gestational

79. Which of the following is NOT a characteristic of pulsatile flow?

- a) Improved microcirculatory patency
- b) Microcirculatory shunting
- c) Higher rate of O<sub>2</sub> consumption
- d) Lower lactate levels
- e) Reduced metabolic acidosis

80. Following damage to a blood vessel, what factor enters circulation and encounters tissue factor, forming an activated complex essential to the extrinsic clotting cascade?

- a) Factor V
- b) Factor X
- c) Prothrombin
- d) Factor XII
- e) Factor VII

81. Your patient is on VV ECMO and has a high pre-oxygenator SO<sub>2</sub> of 95% and a low patient SO<sub>2</sub> of 70%, what is happening?

- a) Clinically significant recirculation
- b) Patient's CO is high and ECMO flows are low
- c) Oxygenator failure
- d) North-south syndrome
- e) A clot in the oxygenator

82. Which of the following is true about potassium channel blockers?

- a. They are class IV drugs
- b. They work by decreasing SA nodal conduction
- c. Diltiazem is a common drug in this class
- d. They work on fast type ventricular cells

83. What is the most significant preoperative risk factor for kidney damage?

- a) Peripheral vascular disease
- b) Elevated creatinine and BUN levels
- c) Pre-existing renal disease
- d) Preoperative hyperglycemia
- e) Advanced age

84. Which of the following tests is often done on diabetics to reflect their average blood glucose levels over the past three months?

- a) Fasting plasma glucose level
- b) Oral glucose tolerance test
- c) A1C hemoglobin test
- d) Random plasma glucose level

85. Large amounts of atelectasis can reduce the buffer capacity against large changes in alveolar PaO<sub>2</sub> and subsequently systemic arterial PaO<sub>2</sub>. Which of the following reasons explains this?

- a) Increased pulmonary shunting
- b) Increased alveolar-arterial oxygen difference
- c) Reduced functional residual capacity.
- d) Reduced lung compliance

86. Which of the following cells are formed in the alveoli and are indicative of congestive heart failure?

- a) Langerhans cells
- b) Siderophages
- c) Kupffer cells
- d) Basophils

87. Which of the following is fixed dual-chamber pacing?

- a) VOO
- b) DOO
- c) DVI
- d) DDD
- e) AOO

88. Which of the following cells is most often seen in the earliest stages of acute inflammation?

- a) Neutrophils
- b) Eosinophils
- c) Basophils
- d) Lymphocytes
- e) Monocytes

89. Which of the following is a disadvantage of VADs, and not one of ECMO?

- e. Need a dedicated team
- f. ICU monitoring
- g. More bleeding
- h. Can't be used with respiratory failure

90. A benzodiazepine with a short half-life that is most commonly used to reverse respiratory depression in an opioid overdose is

- a. Flumazenil
- b. Lorazepam
- c. Phenobarbital
- d. Alprazolam
- e. Diazepam

91. The only source of oxygen for the placenta comes from:

- e. The maternal uterine veins
- f. The maternal uterine arteries
- g. The mother's lungs
- h. The umbilical cord

92. Which commercial preparation of heparin is used in the US and Europe?

- a) Bovine lung tissue
- b) Porcine intestinal mucosa

93. Which of the following indicates a leakage across the tourniquet site in an isolated limb perfusion case?

- a) Reduction in volume
- b) Increase in volume
- c) No change in volume
- d) All the above are possible

94. What percent of cardiac output should a flow rate be when a patient is on VV ECMO?

- e. 30-80%
- f. 85-90%
- g. 30-90%
- h. 20%

95. Mild to moderate hypotension secondary to rapid administration of protamine is which of the following types of protamine reactions?

- a) Type A
- b) Type B
- c) Type C

96. Which of the following is a list of functional organization of human bodies in correct order from smallest to largest?

- a) Organism, Organelle, Macromolecule, Tissue, System
- b) Molecule, Organelle, Cell, Tissue, Organ
- c) Atom, Cell, Macromolecule, Organ, Tissue
- d) Organelle, Molecule, Macromolecule, System, Organ

97. Which of the following best describes the test parameter sensitivity?

- a) The proportion of people without the disease who test positive
- b) The proportion of people without the disease who test negative
- c) The proportion of people with the disease who test negative
- d) The proportion of people with the disease who test positive
- e) None of the above

98. Which of the following describes the changes in hemodynamics associated with protamine reactions?

- a) ↑ PA pressure and CVP, ↓ systemic arterial pressure
- b) ↑ CVP, ↓ PA and systemic arterial pressures
- c) ↑ systemic arterial pressures, ↓ CVP and PA pressure
- d) ↑ systemic arterial and PA pressures, ↓ CVP
- e) ↑ systemic arterial pressure, PA pressure, and CVP

99. Low flow CPB is most similar to what other perfusion technique?

- e. SCP
- f. RCP
- g. ACP
- h. Isolated limb perfusion

100. HMIII: Your patient is 4 hours postop and has the following parameters: CVP = 25 mmHg, PI = 2.7, flow = “---“, but is alarming with a red heart for low flow, speed = 8600, and power = 5.6. Your patient is on Primacor and Flolan. What should be done/given?

- a) Diuretics

- b) 5% albumin
- c) Tissue plasminogen activator
- d) RVAD placement
- e) ACE inhibitors

ANSWERS:

1. C, A, A, B, B, B, D, D, C, B, A, A, E, D, A, D, D, A, C, D, A, D, B, C, A  
 26. B, F, B, C, D, C, E, C, D, E, A, E, B, E, D, C, D, A, A, B, E, C, B, B, D  
 51. C, A, D, B, C, B, D, B, E, E, A, B, C, D, C, D, D, A, C, B, A, D, B, D, D  
 76. A, E, B, B, E, A, D, C, C, C, B, B, A, D, A, A, B, D, C, A, B, D, A, A, D

**PRACTICE EXAM 4 – 100 QUESTIONS AND ANSWERS**

1. Centrifugal pumps are preload (dependent/independent) and afterload (dependent/independent).
- a) Dependent, dependent
  - b) Dependent, independent
  - c) Independent, dependent
  - d) Independent, independent
2. Which of the following hormones stimulates red blood cell production?
- a) Glucagon
  - b) Calcitriol
  - c) Erythropoietin
  - d) Somatostatin
  - e) Parathyroid hormone
3. A patient has a pH of 7.28, a pCO<sub>2</sub> of 41, and a HCO<sub>3</sub> of 17. This patient most likely has:
- a. Respiratory depression
  - b. Hyperventilation
  - c. Renal failure

- d. Sodium Bicarbonate overdose
4. An individual has increased renal glomerular permeability to proteins that is not due to inflammation. This is most likely
- a) Nephrotic syndrome
  - b) Nephritic syndrome
  - c) Isolated hematuria
  - d) Polycystic kidney disease
  - e) DIC
5. The vertebral artery is a branch of the
- a) Subclavian artery
  - b) Common carotid artery
  - c) Brachiocephalic artery
  - d) Internal carotid artery
  - e) External carotid artery
6. Which of the following is an effective method in reducing excitatory neurotransmitter release (e.g., glutamate), thereby attenuating the excitotoxic cascade?
- a) Hemodilution
  - b) Hypothermia
  - c) Hyperglycemia
  - d) Hypocalcemia
  - e) None of the above
7. Which of the following can reduce cerebral metabolic rate during CPB?
- a) Decrease in temperature, increase in sedative-hypnotic agents
  - b) Decrease in temperature, decrease in sedative-hypnotic agents
  - c) Increase in temperature, increase in sedative-hypnotic agents
  - d) Increase in temperature, decrease in sedative-hypnotic agents
8. Which of the following would be an appropriate way to treat disseminated intravascular coagulopathy (DIC) if caught in the clotting phase?
- a) Heparinization to prevent consumption until factors can be replenished by the liver/artificially
  - b) Continuous supply of blood products until coagulation factor levels have stabilized
9. A wide QRS complex seen on the ECG is most likely due to which of the following conditions?
- a) Hyperkalemia
  - b) Hypercalcemia
  - c) Hypocalcemia
  - d) Hypokalemia
  - e) Hyponatremia
10. Which anatomic location is the most susceptible to aortic dissection?

- a) Aortic arch
  - b) Thoracic aorta
  - c) Abdominal aorta
  - d) Ascending aorta
11. Which of the following receptors is responsible for dilation of the pupil?
- a) Alpha 1
  - b) Alpha 2
  - c) Beta 1
  - d) Beta 2
  - e) Muscarinic 2
  - f) Muscarinic 3
  - g) Nicotinic (n)
  - h) Nicotinic (m)
12. In the 3-letter NBG code, what does the third letter indicate?
- a) Chamber paced
  - b) Sensed response
  - c) Chamber sensed
13. Varicose veins are caused by
- a) Increased number of venous valves
  - b) Decreased number of arterial valves
  - c) Arterial valve incompetency
  - d) Venous valve incompetency
  - e) Arterial blood backflow
14. A loading dose of 400 U/kg was given for bypass. An ACT was drawn five minutes after and came back at 290 seconds. Which of the following would be the most appropriate next step?
- a) Put 10,000 units of heparin in the pump and go on bypass
  - b) Draw a second ACT to check if the first one was correct
  - c) Administer another 200 U/kg of heparin then draw a second ACT
  - d) Give ATIII (e.g., Thrombate III)
  - e) Administer two units of fresh frozen plasma (FFP)
15. Protamine-sulfate, which neutralizes heparin, was discovered by:
- a) Howell & Holt
  - b) Brauer & Sauerbruch
  - c) Gibbon
  - d) Sones
  - e) Chargraff & Olson

16. The heartmate III is a long-term mechanical assist device. It follows a different principle of flow than other devices, such as the Berlin Heart or the Heartmate II. What type of pump does the Heartmate III use to obtain flow to the patient?

- e. Pulsatile
- f. Centrifugal
- g. Roller
- h. Axial

17. All of the following regarding exchange across the capillary wall are true under normal conditions, EXCEPT

- a) Capillary pressure pushes fluid out of a capillary
- b) Interstitial fluid pressure pushes fluid into capillary
- c) Plasma colloid osmotic pressure pulls fluid into capillary
- d) Interstitial fluid colloid osmotic pressure pulls fluid out of capillary
- e) There is a small net flux into the capillary

18. How should central venous pressure (CVP) be interpreted?

- a) Afterload
- b) Preload
- c) Can indicate right ventricle status
- d) a + c
- e) b + c

19. A new technique for ruling out HIV is used to test 1,000 people without the disease. Of those tested, 999 came back with a negative result using the new technique. This new diagnostic technique has

- a) High sensitivity
- b) Low sensitivity
- c) High specificity
- d) Low specificity

20. Which of the following is not a feature of preeclampsia?

- a) Hypertension
- b) Proteinuria
- c) Seizures
- d) Common in first pregnancies
- e) Common in pregnant diabetics

21. You notice your patient is being hypoperfused and you have very high line pressure. What should be your treatment?

- a) Check roller pump occlusion
- b) ↑ pump flow; ↑ gas sweep rate; ↑ hematocrit (if low)
- c) Alert the surgeon and decrease or stop flow

22. Which of the following colloids may not be acceptable for Jehovah's Witness patients?

- a) Dextran
  - b) Hetastarch
  - c) Albumin
23. Which of the following is NOT a drainage site for left heart bypass?
- a) Left inferior pulmonary vein
  - b) Left atrium
  - c) Left subclavian
  - d) Right atrium
24. The PO<sub>2</sub> of inhaled air (i.e. in the airways) at sea level is slightly \_\_\_\_\_ than the PO<sub>2</sub> of ambient air because of the impact of \_\_\_\_\_.
- a. Lower ; water vapor
  - b. Lower ; pressure
  - c. Higher ; water vapor
  - d. Higher ; pressure
25. When clotting factors become inappropriately activated by a triggering event and then are exhausted as a result leading to uncontrolled systemic bleeding this is known as what condition?
- a) Primary fibrinolysis
  - b) Type 2 heparin-induced thrombocytopenia
  - c) Thrombocytopenic purpura
  - d) Disseminated intravascular coagulopathy
  - e) Type 1 heparin-induced thrombocytopenia
26. Which of the following correctly describes the feedback system in blood clot dissolution?
- a) Kallikrein positively feeds back to deactivate FXII
  - b) Kallikrein positively feeds back to activate FXII
  - c) Kallikrein negatively feeds back to deactivate FXII
  - d) Kallikrein negatively feeds back to activate FXII
27. Which of the following would decrease blood flow through a vessel?
- a) Increasing the radius
  - b) Decreasing the pressure drop across the vessel
  - c) Decreasing the length of the vessel
  - d) Decreasing the viscosity
  - e) Decreasing the resistance
28. A patient is currently taking a drug that will irreversibly inhibit cyclooxygenase. The drug is most likely:
- a. Warfarin
  - b. Aspirin

- c. Clopidogrel
- d. Abciximab
- e. Aminocaproic Acid

29. Most of the posterior aspect of the heart (as it lies in the chest) is formed by the

- a) Left atrium
- b) Right atrium
- c) Right ventricle
- d) Left ventricle

30. Which of the following congenital heart defects is a acyanotic lesion?

- e. TOF
- f. Single ventricular anatomy
- g. Coarctation of the aorta
- h. D-transposition of the great arteries

31. Which of the following ion concentrations often shows significant changes after administering old banked blood?

- a) Sodium
- b) Chloride
- c) Phosphorus
- d) Magnesium
- e) Potassium

32. What is the role of the anesthesia monitoring tech in the OR?

- a) Directly assists the surgeon at the table
- b) Organizes and hands instruments at the table
- c) Helps prepare the monitoring lines, labs, and assists anesthesia
- d) Stays in the room and assists in opening supplies, answering the phone, etc.

33. Which of the following drugs may cause hypernatremia?

- a) Tris hydroxymethyl aminomethane (THAM)
- b) Lidocaine
- c) Adenosine
- d) Calcium gluconate
- e) Bicarbonate

34. Which of the following is NOT an indication for intraoperative use of an electrocardiogram (ECG)?

- a) Diagnosis of dysrhythmias
- b) Diagnosis of ischemia
- c) Diagnosis of volume status
- d) Diagnosis of conduction defects
- e) Monitor effect of cardioplegia during the aortic cross-clamp period

35. Which of the following cardioplegia constituents is an intermediary in the citric acid cycle that is used to help replenish ATP stores?
- Mannitol
  - Nicorandil
  - Adenosine
  - Lidocaine
  - Aspartate
36. Which of the following shunts fetal blood from the pulmonary trunk to the aorta?
- Umbilical vein
  - Umbilical artery
  - Ductus arteriosus
  - Ductus venosus
  - Foramen ovale
37. Which of the following is most responsible for maintaining GFR and increasing reabsorption when the blood pressure is low?
- Renin
  - Angiotensin I
  - Angiotensin II
  - Aldosterone
  - NaCl
38. You notice your patient is being hypoperfused and you have an abnormally low arterial line pressure. What should be your treatment?
- Alert the surgeon and decrease or stop flow
  - Check roller pump occlusion
  - ↑ pump flow; ↑ gas sweep rate; ↑ hematocrit (if low)
39. What is the standard CPB flow rate for a patient that is morbidly obese?
- 2.0 – 2.5 L/min/m<sup>2</sup>
  - 1.8 – 2.0 L/min/m<sup>2</sup>
  - 1.6 – 1.8 L/min/m<sup>2</sup>
  - 3.0 – 3.2 L/min/m<sup>2</sup>
  - 2.8 – 3.4 L/min/m<sup>2</sup>
40. Which protamine reaction is due to a heparin-protamine interaction which activates the classic complement pathway?
- Histamine reaction
  - Anaphylactic reaction
  - Anaphylactoid reaction
  - Pheresis reaction
41. Why may a patient still be ejecting with an effectively drained right heart on CPB?
- The patient has aortic insufficiency
  - Anesthesia is still ventilating

- c) The venous cannula is too small
  - d) Systemic vascular resistance is high
  - e) The patient has aortic stenosis
42. Vegetation from endocarditis most commonly affects which valve in the heart?
- e. Mitral
  - f. Tricuspid
  - g. Aortic
  - h. Pulmonary
43. If an individual had all 4 limbs removed, what would happen to a patient's cardiac output, arterial pressure, and total peripheral resistance, respectively?
- a) Decrease, decrease, increase
  - b) Increase, increase, increase
  - c) Increase, decrease, increase
  - d) Decrease, decrease, decrease
  - e) Decrease, increase, increase
44. What is considered the largest source of hemolysis in the CPB circuit?
- a) Arterial cannula
  - b) Venous cannula
  - c) Tip of cardioplegia needle
  - d) Cardiectomy filter
  - e) Pump suckers
45. Which of the following is within the normal range for antithrombin-III (AT-III) levels?
- a) 200 mg/dL
  - b) 5 mg/dL
  - c) 100 mg/dL
  - d) 150,000 mg/dL
46. What are the normal arterial and venous lactate range?
- a) Arterial 0.3 – 0.8 mmol/L, venous 0.6 – 2.2 mmol/L
  - b) Arterial 0.8 – 1.2 mmol/L, venous 0.3 – 0.6 mmol/L
  - c) Arterial 1.7 – 2.3 mmol/L, venous 4.5 – 5.6 mmol/L
  - d) Arterial 3.0 – 4.0 mmol/L, venous 3.5 – 4.5 mmol/L
  - e) Arterial 1.0 – 1.4 mmol/L, venous 9.7 – 10.5 mmol/L
47. What is the primary issue with air left in a sample syringe filled with blood?
- a) Causes hemolysis of red blood cells which can increase sample potassium
  - b) Activates platelets in the sample resulting in sample hemostasis
  - c) Introduction of particulate from the air can alter lab readings
  - d) Activates leukocytes which release chemotactic factors that can alter lab readings
  - e) Room air gases will begin to equilibrate with blood sample gases
48. What is normal arterial and venous pCO<sub>2</sub>?

- a) Arterial: 46 mmHg, Venous: 40 mmHg
  - b) Arterial: 100 mmHg, Venous: 40 mmHg
  - c) Arterial: 100 mmHg, Venous: 46 mmHg
  - d) Arterial: 160 mmHg, Venous: 100 mmHg
  - e) None of the above
49. What is the recommended gas to blood flow ratio (GBFR) for most oxygenators?
- a) 5:1
  - b) 2:1
  - c) 3:1
  - d) 1:2
  - e) 1:4
50. What is an appropriate coronary sinus pressure for retrograde delivery of cardioplegia?
- a) 2 – 10 mmHg
  - b) 30 – 100 mmHg
  - c) 20 – 70 mmHg
  - d) 15 – 50 mmHg
  - e) 20 – 35 mmHg
51. During pH-stat acid-base management, after you significantly increase pCO<sub>2</sub>, what happens to cerebral autoregulation?
- a) No change in cerebral autoregulation, cerebral metabolic rate is matched with cerebral blood flow
  - b) Autoregulation is lost due to the uncoupling of cerebral blood flow to cerebral metabolic rate
  - c) Increase in autoregulatory capacity with changes in pressures
  - d) Decrease in autoregulatory capacity with changes in pressures
52. What defect is associated with an atrioventricular canal (AVC)?
- e. Sinus Venosus ASD
  - f. Subarterial VSD
  - g. Septum secundum ASD
  - h. Inlet VSD
53. Furosemide's main mechanism of action works in which area of the nephron?
- a. Ascending limb, loop of Henle
  - b. Collecting duct
  - c. Descending limb, loop of Henle
  - d. Distal convoluted tubule
  - e. Proximal tubule
54. Which of the following is a monoclonal antibody preparation that can be used to treat many breast cancers because it can target human epidermal growth factor receptor?
- a. Methotrexate
  - b. Tacrolimus

- c. Cyclophosphamide
- d. Trastuzumab

55. A 21-year-old college football player has excessive bruising after a game 2 days ago. He took two aspirin tablets before the game because his knees were sore. He was tackled several times during the game, but otherwise has had no trauma. Which of the following labs is likely to be found abnormal on a blood test?

- a) Activated PTT
- b) Bleeding Time
- c) INR
- d) platelet count
- e) PT

56. What is the target flow rate for retrograde cerebral perfusion (RCP)?

- a) 1 – 2 L/min
- b) 25 – 50 mL/min
- c) 100 – 500 mL/min
- d) 350 – 800 mL/min
- e) 900 – 1100 mL/min

57. Which of the following is an eicosanoid that stimulates platelet aggregation?

- a) Leukotriene
- b) Prostacyclin
- c) Prostaglandin
- d) Thromboxane

58. A dissection involving only the descending aorta is what type of Stanford dissection?

- a) Type 1
- b) Type 2
- c) Type 3
- d) Type A
- e) Type B

59. Your surgeon tells you to give a maintenance dose of cardioplegia in the middle of a mitral valve procedure. What delivery route will this most likely be?

- a) Antegrade
- b) Retrograde
- c) Ostial

60. What is the final step in the sterilization process for supplies with lumens?

- a) Alcohol bath
- b) UV light
- c) Ethylene oxide

- d) Autoclave
61. Which of the following modes has the potential for R on T, leading to VT or VF?
- a) DVI
  - b) AOO
  - c) DOO
  - d) AAI
  - e) VOO
62. How long should a surgeon allow a period of no flow during DHCA?
- e. Less than 15 minutes
  - f. No more than 40 minutes
  - g. 25 minutes
  - h. 30 minutes
63. The radial artery is a branch of the
- a) Ulnar artery
  - b) Brachial artery
  - c) Axillary artery
  - d) Subclavian artery
64. Which of the following anesthetics is a drug of choice if something is needed for both induction and maintenance of anesthesia?
- a. Etomidate
  - b. Propofol
  - c. Isoflurane
  - d. Ketamine
  - e. Dexmedetomidine
65. Which of the following is a common order of events for adult heart anastomoses?
- a) PA → LA → aorta → IVC → SVC
  - b) PA → LA → IVC → SVC → aorta
  - c) LA → PA → aorta → IVC → SVC
  - d) LA → PA → IVC → SVC → aorta
  - e) Aorta → LA → PA → IVC → SVC
  - f) Aorta → PA → LA → IVC → SVC
66. Which of the following would NOT improve O<sub>2</sub> delivery to tissues?
- a) Decreasing pH
  - b) Decreasing pCO<sub>2</sub>
  - c) Increasing temperature
  - d) Increasing 2,3 DPG
  - e) None of the above

67. What is the normal range for pulmonary artery pressure (PAP)?
- a) 15 – 20 mmHg / 10 – 15 mmHg
  - b) 15 – 25 mmHg / 8 – 10 mmHg
  - c) 20 – 35 mmHg / 8 – 15 mmHg
  - d) 15 – 40 mmHg / 10 – 20 mmHg
  - e) 20 – 25 mmHg / 0 – 8 mmHg
68. What variation of hemoglobin A results in sickle cell anemia?
- a) Hemoglobin S
  - b) Hemoglobin C
  - c) Hemoglobin E
  - d) Hemoglobin H
69. Which of the following conditions increases the risk of kidney stone formation?
- a) Low solute concentration
  - b) High urine output
  - c) Low urine calcium concentration
  - d) High urine magnesium concentration
  - e) Low urine citrate concentration
70. Which of the following drugs used for hypertension is linked to fetal death by crossing the placental membrane and liberating free cyanide ions?
- a) Hydralazine
  - b) Nitroprusside
71. Which of the following is NOT a type of macromolecule?
- a) Carbohydrates
  - b) Proteins
  - c) Lipids
  - d) Amino Acids
  - e) Nucleic Acids
72. An interrupted aortic arch that has an interruption proximal to the left subclavian is defined as:
- e. Type A
  - f. Type B
  - g. Type C
  - h. Type 4
73. During HIPEC you notice your patient's nasal temperature becomes hyperthermic. All the following would be appropriate actions to take EXCEPT?
- a) Decrease room temperature
  - b) Use a Bair Hugger on ambient temperature
  - c) Reducing heater-cooler temperature
  - d) Pack the axilla with ice

- e) Use a cooling jacket
74. Which of the following is a common cause of respiratory alkalosis?
- a) Anxiety attack
  - b) Diarrhea
  - c) Emesis
  - d) Severe asthma attack
  - e) Renal disease
75. Which of the following is a fungal infection of the lungs that is found primarily in the southwest US?
- a) Coccidioidomycosis
  - b) Histoplasmosis
  - c) Blastomycosis
  - d) Candidiasis
76. The primary transmitter at parasympathetic postganglionic nerve endings is
- a. Acetylcholine
  - b. Enkephalin
  - c. GABA
  - d. Nitric Oxide
  - e. Norepinephrine
77. Which of the following would be a normal arterial pH?
- a) 7.31
  - b) 8.00
  - c) 7.49
  - d) 7.42
  - e) 7.14
78. Which of the following has the greatest effect on blood flow?
- a) Length of vessel
  - b) Radius of vessel
  - c) Viscosity of fluid
  - d) Pressure
  - e) Turbulence
79. What is the target flow rate for ACP via innominate cannulation?
- a) 500 – 800 mL/min
  - b) 20 – 40 cc/kg/min
  - c) 100 – 500 mL/min
  - d) 40 – 50 cc/kg/min
  - e) 800 – 1000 mL/min

80. Repeated, rapid stimulation of a skeletal muscle fiber results in tetanus. Tetanus occurs when intracellular concentrations of which of the following remains elevated?

- a) Na<sup>+</sup>
- b) K<sup>+</sup>
- c) Cl<sup>-</sup>
- d) ATP
- e) Ca<sup>2+</sup>
- f) Troponin

81. Applying excessive vacuum (i.e., > 50 mmHg) while using a roller head can cause which of the following to occur?

- a) The pump becomes afterload dependent
- b) Levels of spallation increases
- c) Stroke volume is reduced
- d) The pump becomes preload independent
- e) Tubing rupture

82. A farmer was exposed to an organophosphate and was given a dose of atropine to reduce his symptoms. Which of the following will continue to be overactivated by excess acetylcholine even after atropine is given?

- a. Airway smooth muscle
- b. S-A node of the heart
- c. Salivary and lacrimal glands
- d. Skeletal muscle
- e. Vascular smooth muscle

83. Which of the following is NOT a muscle of inspiration?

- a) Muscles of the anterior abdominal wall
- b) External intercostal
- c) Internal intercostal
- d) Serratus posterior inferior
- e) Diaphragm

84. Which of the following parameters is most characteristic to changing post-cross-clamp removal?

- a) Urine output
- b) Cerebral saturations
- c) Core temperature
- d) Systemic vascular resistance
- e) Bispectral index

85. A 71-year-old male has a form of COPD where his acini are uniformly enlarged from the level of the respiratory bronchiole to the terminal blind alveoli. This is most likely

- a) Centriacinar emphysema
  - b) Panacinar emphysema
  - c) Distal acinar emphysema
  - d) Paraseptal emphysema
  - e) Chronic bronchitis
86. A potential cause of secondary hypertension may be
- a) Increased salt intake
  - b) Lack of exercise
  - c) Obesity
  - d) Kidney disease
87. How is tubing sterilized?
- a) Alcohol bath
  - b) Ultraviolet light
  - c) Ethylene oxide
  - d) Autoclave
  - e) Ultrasonic washer
88. Nitroglycerin is commonly used as a first line of defense for angina pectoris. This is due to nitroglycerin's ability to
- a. Decrease intracellular calcium
  - b. Block catecholamine release
  - c. Decrease ventricular preload and arterial afterload
  - d. Inhibit guanylate cyclase and resultant cyclic guanine nucleotides
89. You notice your patient is being hypoperfused and you have normal arterial line pressure. What should be your treatment?
- a) ↑ pump flow; ↑ gas sweep rate; ↑ hematocrit (if low)
  - b) Check roller pump occlusion
  - c) Alert the surgeon and decrease or stop flow
90. If the only acid/base mechanism operating is ventilation, which of the following statements would most likely be true?
- a) As the rate of alveolar ventilation increases, pH in body tissues increases
  - b) As the rate of alveolar ventilation increases, pH in body tissues decreases
  - c) As the rate of alveolar ventilation decreases, pH in the body increases
  - d) As the rate of alveolar ventilation decreases, pH in the body remains constant
91. Which of the following describes microplegia?
- a) Ratio system of blood:crystalloid

- b) Concentrated additives added to the blood
  - c) Straight crystalloid
92. Which of the following describes an ideal priming solution (relative to the patient's parameters) to use for bypass?
- a) Similar electrolyte content, slightly hypotonic solution
  - b) Similar electrolyte content, slightly hypertonic solution
  - c) High electrolyte content, slightly hypotonic solution
  - d) High electrolyte content, slightly hypertonic solution
  - e) Low electrolyte content, isotonic solution
  - f) Low electrolyte content, slightly hypertonic
93. Platelets are slowly rocked to prevent clumping at what temperature?
- a) 1 – 6 °C
  - b) 20 – 24 °C
  - c) ≤ -18 °C
  - d) 21 – 35 °C
  - e) 10 – 15 °C
94. Why is retrograde cardioplegia ineffective at protecting the right heart?
- a) The right heart has valves which prevent cardioplegia from reaching it and thus protecting it
  - b) Veins from the RV drain directly into the RA
  - c) Retrograde cardioplegia catheters are directed leftward, not rightward
95. Which of the following would most likely increase the anion gap?
- a) Diarrhea
  - b) Carbonic anhydrase inhibitors
  - c) Saline infusion
  - d) Renal tubular acidosis
  - e) Diabetic ketoacidosis
96. Which of the following components of the neuron is most responsible for receiving signals?
- a. Dendrite
  - b. Perikaryon
  - c. Soma
  - d. Axon
  - e. Node of Ranvier
97. A patient suffers from large amounts of fluid filling the pericardial space. When he takes a deep inspiration, he has a drop in systolic blood pressure of 15 mmHg. This patient most likely has
- a) Pancarditis
  - b) Acute pericarditis

- c) Pericardial tamponade
- d) Constrictive pericarditis

98. A blood sample is taken for a lab, what is the time limit that the sample should sit at room temperature before being tested?

- a) 10 minutes
- b) 15 minutes
- c) 2 minutes
- d) 5 minutes
- e) 30 seconds

99. Which connection would be the best option to shunt portal blood around the liver in a patient with cirrhotic portal hypertension?

- a) Superior mesenteric vein to inferior mesenteric vein
- b) Portal vein to SVC
- c) Portal vein to left renal vein
- d) Splenic vein to left renal vein

100. What is the normal range for right ventricular pressure (RVP)?

- a) 15 – 25 / 2 – 6 mmHg
- b) 15 – 20 / 0 – 8 mmHg
- c) 10 – 20 / 0 – 6 mmHg
- d) 20 – 25 / 0 – 8 mmHg
- e) 10 – 30 / 2 – 10 mmHg

**ANSWERS:**

1. A, C, C, A, A, B, A, A, A, D, A, B, D, C, E, B, E, E, C, C, C, C, D, A, D

26. B, B, B, A, C, E, C, E, C, E, C, C, B, B, C, A, B, A, E, C, A, E, E, B, E

51. B, D, A, D, B, C, D, E, B, C, E, B, B, B, C, B, B, A, E, B, D, B, C, A, A

76. A, D, B, A, E, C, D, C, D, D, D, C, C, A, A, B, B, B, B, E, A, C, A, D, B

## Appendix G: Sample Tests – Questions and Answers

This appendix features all the multiple-choice questions and answers created for Sample Tests 1-3 that was uploaded to Quizlet.

### SAMPLE TESTS ONE THROUGH THREE

#### SAMPLE TEST 1

- Which of the following normally has the lowest blood pO<sub>2</sub>?
  - maternal artery
  - umbilical artery
  - umbilical vein
  - fetal ascending aorta
- Which of the following does not describe the azygous system?
  - The azygous system contains three unpaired veins forming a long collecting trunk.
  - The azygous vein arises in the abdomen near where the renal vein enters the inferior vena cava.
  - The azygous vein travels through the transverse groove between the left cardiac auricle and the left ventricle.
  - The intercostal veins drain into the azygous system.
- Which of the following is the proper order of aortic arch vessels (from proximal to distal)?
  - R subclavian - R carotid - L innominate
  - R innominate - L common carotid - L subclavian
  - R internal carotid - L subclavian - L internal thoracic
  - R innominate - L subclavian - L common carotid
- The Glenn Procedure creates a shunt between the:
  - aorta and main PA
  - LA and RA
  - SVC and right PA
  - aorta and right PA
  - aorta and left PA
- What is the name of the subclavian to PA anastomosis?
  - Blalock - Taussig
  - Blalock - Hanlon
  - Glenn shunt
  - Ebstein shunt
- In a patient with mitral stenosis, blood is prevented from readily flowing from

- A. the left ventricle to the aorta.
  - B. the left atrium to the left ventricle.
  - C. the right atrium to the pulmonary artery.
  - D. the right atrium to the right ventricle.
7. Which of the following is a useful agent in combating the deleterious effects of hyperkalemia on the heart?
- A. chloride
  - B. sodium
  - C. magnesium
  - D. calcium

8. The initiation of respiration in the newborn infant pulmonary vascular resistance and \_\_\_\_\_ the pulmonary arterial pressure. (I- Increase, D-Decrease)
- A. I,I
  - B. I,D
  - C. D,I
  - D. D,D
9. The major branches of the left coronary artery are:
- A. the anterior descending and the posterior descending
  - B. the marginal branch and the circumflex branch
  - C. the circumflex branch and the anterior descending branch
  - D. the marginal branch and the anterior descending branch
10. What is the most prevalent type of ASD?
- A. ostium primum
  - B. ostium secundum
  - C. sinus venosus
  - D. truncus arteriosus
11. The terminal branches of the abdominal aorta are the:
- A. common iliac arteries
  - B. choroidal arteries
  - C. femoral arteries
  - D. popliteal arteries
12. Which type of VSD is located between the pulmonary valve and the crista supraventricularis?
- A. Type I
  - B. Type II
  - C. Type III
  - D. Type IV
13. What is the most common type of VSD?
- A. type I
  - B. type II
  - C. type III
  - D. type IV
14. Kawasaki disease is
- A. an aneurysm of the ascending aorta.
  - B. an aneurysm of the abdominal aorta.
  - C. an aorto-pulmonary window.
  - D. an aneurysm of a coronary artery.

15. Which of the following may be associated with Pentalogy of Fallot?
- ASD
  - IHSS
  - Pulmonary atresia
  - Vascular rings
16. Choose the most correct statement:
- Truncus arteriosus results from an underdevelopment of the ventricular septum.
  - An ASD has a higher frequency of occurrence of cardiac malformation at birth than a VSD.
  - A VSD has a lower frequency of occurrence of cardiac malformation at birth than an ASD.
  - Pulmonary hypotension caused by any of several factors and leading to the development of right heart failure is known as cor pulmonale.
17. Choose the correct statement from the following series.
- The visceral pericardium and the epicardium refer to the two types of pericardium.
  - The conus artery is a branch of the left coronary artery found in approximately half of the population.
  - The membranous portion of the ventricular septum is comprised of mostly myocardial tissue.
  - In approximately 75% of the population, the AV node is supplied by the posterior septal branch of the RCA.
18. The majority of the population is their \_\_\_\_\_ dominant with respect to coronary artery system.
- right
  - left
  - balanced (non-dominant)
  - superior
19. A Pott's operation is an anastomosis of the:
- ascending aorta to the left pulmonary artery
  - descending aorta to the pulmonary artery branch
  - subclavian artery to the pulmonary artery branch
  - ascending aorta to the subclavian artery
20. A PFO in a newborn can be categorized as what type of shunt?
- restrictive
  - non-restrictive
  - complex
  - cyanotic

21. Which of the following depicts the proper sequence of the cardiac conduction system?
- A. AV node - SA node - Right and left bundle branches - Purkinje fibers
  - B. SA node - AV node - Purkinje fibers - Right and left bundle branches
  - C. SA node - AV node - Bundle of His - Purkinje fibers
  - D. SA node - AV node - Purkinje fibers - Bundle of His
22. Which of the following is not a true statement?
- A. The myocardium contains muscle fibers.
  - B. The innermost layer of cardiac tissue holds a slightly negative electrical charge.
  - C. The endocardium covers the cardiac valves.
  - D. The epicardium is distinct from the other layers of tissue due to its double layer of mesothelial cells.
23. Cardiac impulses normally originate in a structure located in the right atrium called the:
- A. AV node
  - B. SA node
  - C. Purkinje fibers
  - D. Bundle of His
24. The Rastelli procedure consists of:
- A. shunt RA - PA
  - B. shunt RV - PA
  - C. atrial septostomy
  - D. shunt desc. Ao - PA
25. Under normal circumstances, the only bicuspid valve in the body is the:
- A. tricuspid
  - B. pulmonic
  - C. mitral
  - D. aortic
26. The secretion of a diminished amount of urine in relation to fluid intake is called:
- A. oliguria
  - B. polyuria
  - C. anuria
  - D. dysuria
27. The most common type of anomalous venous return is:
- A. supracardiac
  - B. cardiac
  - C. infracardiac
  - D. cardiac

28. Treatment for a blood transfusion reaction should include which of the following modalities?
- A. administration of benzodiazepines, nitroprusside, and hydroxyethyl starch solution
  - B. administration of platelets, fresh frozen plasma, and cryoprecipitate
  - C. administration of steroids, diuretics, and heparin
  - D. administration of vasopressors, antibiotics, and cryoprecipitate
29. Prostaglandin E1 does not
- A. cause hypotension.
  - B. cause seizures.
  - C. produce apnea in infants.
  - D. decrease the rate of glomerular filtration.
30. Which of the following is a true statement?
- A. The small molecular size of Mannitol makes it an effective diuretic.
  - B. Reabsorption of Na<sup>+</sup> and Cl<sup>-</sup> in the ascending loop of Henle, proximal tubule, and distal tubule is promoted by Furosemide.
  - C. Hypocalcemia is usually a result of Edecrine treatment.
  - D. Potassium replacement is usually necessary with the use of Lasix.
31. The treatment for malignant hypertension is:
- A. dantrium
  - B. dantrolene
  - C. trimethaphan camsylate
  - D. thorazine
32. Which of the following is not an alternative to heparin utilization in conjunction with CPB?
- A. ancrod
  - B. protamine
  - C. hirudin
  - D. heparinoid
33. Which of these drugs acts on the receptors at the motor-end plates and is commonly used for intubation?
- A. anectine
  - B. verapamil
  - C. solumedrol
  - D. lasix
34. All of the following cause vasodilation except:
- A. trimethaphan
  - B. apresoline
  - C. vasoxtol
  - D. arfonad

35. Atropine and Scopolamine administration might result in which of the following?
- A. Increased heart rate
  - B. Increased secretions
  - C. No sedative effects
  - D. Vagal stimulation
36. The initial heparinizing dose for the average open heart patient is generally:
- A. 200-300 units/kg of body weight
  - B. 2-4 mg/lb of body weight
  - C. 0.3 cc per kilogram of body weight
  - D. 3 cc per kilogram of body weight
37. Pick the incorrect statement.
- A. In the sympathetic nervous system, norepinephrine is the chemical mediator that is stored in granules at dendritic terminals of post- ganglionic neurons.
  - B. Activation of alpha-adrenergic sympathetic receptors often elicits an excitatory tissue response.
  - C. Adrenergic alpha receptor stimulation causes an increase in available energy through metabolic processes.
  - D. In normal individuals, alpha receptors comprise the majority of all cardiac receptor sites.
38. Another name for verapamil is:
- A. cardizem
  - B. calan
  - C. procardia
  - D. nifedepine
39. The major complications of Thiazide diuretic therapy are related to its renal effects and include all of the following except:
- A. hypovolemia
  - B. hypokalemia
  - C. decreased GFR
  - D. metabolic acidosis
40. Which of the following dilates both the arterial and the venous systems in humans?
- A. Phenylephrine
  - B. Nitroglycerine
  - C. Sodium Nitroprusside
  - D. Epinephrine
41. Which of the following statements is not true of protamine?
- A. Protamine has a shorter half-life than heparin.
  - B. Protamine is an inorganic base.
  - C. Protamine binds directly to AT-III.
  - D. Protamine is derived from salmon sperm.

42. A patient being weaned from CPB exhibits ventricular arrhythmias with a rate of 154 BPM. Which of the following drugs would probably be the drug of choice?
- A. Isuprel
  - B. Atropine
  - C. Vasoxyl
  - D. Lidocaine
43. Sufentanil is how many times as potent as Fentanyl?
- A. 80
  - B. 100
  - C. 8
  - D. 10
44. Malignant hyperthermia can be triggered by all of the following except:
- A. succinylcholine
  - B. halothane
  - C. isoflurane
  - D. enflurane
  - E. nitroprusside
45. The main manufacturer of PGE1 during fetal circulation is (are) the
- A. lungs.
  - B. area around the PDA.
  - C. placenta.
  - D. endocrine glands.
46. Which of the following drugs may be used to antagonize opioids?
- A. procardia
  - B. narcan
  - C. valium
  - D. diazepam
47. The Partial Thromboplastin Time (PTT) measures the the \_\_\_\_\_ portion(s) of the coagulation cascade.
- A. extrinsic
  - B. intrinsic
  - C. common
  - D. intrinsic and common
  - E. extrinsic and common
48. Atropine is used to:
- A. increase urine output
  - B. relieve preoperative anxiety
  - C. treat tachycardia
  - D. relax muscles
  - E. treat bradycardia

49. All of the following are platelet active substances except:
- A. persantine
  - B. acetylsalicylic acid
  - C. plavix
  - D. warfarin
50. Pharmacodynamics is best defined as:
- A. The actions of an organism upon a given substance.
  - B. The elimination rate of a given substance from an organism.
  - C. The actions of a given substance upon an organism.
  - D. The method by which an organism distributes a given substance.
51. Halothane
- A. causes less cardiac depression than flurane.
  - B. may have a vasoconstrictive effect.
  - C. produces a widespread CNS depression.
  - D. is often administered in series through the CPB gas line.
52. Low dose dopamine may be used to
- A. increase cardiac output.
  - B. increase renal blood flow.
  - C. increase preload.
  - D. decrease afterload.
53. Dopamine Hydrochloride (Intropin) is sometimes used in conjunction with sodium nitroprusside (Nipride) to
- A. decrease high potassium levels after cardioplegic infusions.
  - B. release calcium originally bound by citrate.
  - C. improve myocardial function curves in the immediate postoperative phase.
  - D. treat severe episodes of sinus tachycardia.
54. The major effect of Dobutamine is:
- A. direct beta-stimulation
  - B. the liberation of norepinephrine
  - C. increased renal blood flow
  - D. negative chronotropy
55. In the process of muscle contraction, as the action potential spreads through the transverse tubule, stored intracellular is released and the actin filaments slide on the myosin filaments.
- A. adenosine
  - B. ATP
  - C. calcium
  - D. troponin
  - E. tropomyosin

56. Which of the following drugs is a skeletal muscle relaxant antagonist?
- A. dantrium
  - B. dilantin
  - C. narcan
  - D. prostigmin
57. Which of the following is a powerful pulmonary vasodilator?
- A. PGE-1
  - B. arfonad
  - C. regitine
  - D. minipress
58. Verapamil has actions similar to those of
- A. bretylium.
  - B. dilantin.
  - C. norpace.
  - D. nifedipine.
59. Which of the following is not a reason why high-dose narcotics are utilized for analgesia?
- A. High-dose narcotics increase SVR or inhibit a rise in PVR for cyanotic lesions.
  - B. High-dose narcotics decrease myocardial O<sub>2</sub> demand with a negative inotropic effect for acyanotic lesions.
  - C. High-dose narcotics are rapidly eliminated in lungs.
  - D. High-dose narcotics are efficiently absorbed from subcutaneous, intramuscular, and mucosal sites.
60. Fluid movement across vascular endothelium to the tissues
- A. is increased by increasing blood protein concentration.
  - B. is decreased by vasodilation of arterioles.
  - C. is elevated by venous pressure increase.
  - D. is unaltered by blood histamine concentration.
  - E. is reduced by the hemodilution of CPB.
61. Hematocrit is defined as:
- A. the amount of hemoglobin in the blood
  - B. the O<sub>2</sub> carrying capacity divided by 1.34
  - C. the total blood cell weight divided by the total blood cell volume
  - D. the percentage of the total blood volume occupied by red blood cells
62. Which of the following will not stimulate platelet aggregation?
- A. Prostacyclin
  - B. ADP
  - C. Serotonin
  - D. Thromboxane A<sub>2</sub>
  - E. Arachidonic acid

63. Which of the following is true of type O blood?
- A. Plasma has O antigen.
  - B. RBC's have A and B antigen.
  - C. Plasma has no A or B antibodies.
  - D. RBC's have no A or B antibodies.
64. Hemoglobin is expressed in which of the following units?
- A. %
  - B. mg of Hgb / 100 cc blood
  - C. g of Hgb / 100 mL blood
  - D. % / kg
65. Clinically significant arterial cyanosis is indicated by the reduction of hemoglobin by
- A. 5 gm/dL.
  - B. 15 gm/dL.
  - C. 25 gm/dL.
  - D. 15 mg/L.
66. A hyperosmotic fluid will cause water to migrate from within the erythrocytes to the exterior of the erythrocytes, resulting in
- A. crenation.
  - B. hemolysis.
  - C. swelling.
  - D. clotting.
67. The relationship between stroke volume and end-diastolic volume is expressed by
- A. the Borelli Principle.
  - B. Marey's Law.
  - C. Starling's Law.
  - D. Boyle's Law.
68. The Prothrombin Time (PT) is a measurement of what function?
- A. extrinsic time
  - B. intrinsic time
  - C. extrinsic time and common pathway
  - D. intrinsic time and common pathway
69. Choose the most correct statement.
- A. Type O blood has anti-A and anti-B agglutinogens in their RBC's.
  - B. Type B blood is the most commonly found blood type, followed by type O, type A, and finally type AB.
  - C. The O negative blood type is know as the universal donor.
  - D. If an Rh negative patient receives Rh positive blood for the first time, a traumatic transfusion reaction will occur.

70. Choose the correct statement.
- A. Mannitol is a loop diuretic.
  - B. Mannitol works to produce a diuresis by retaining water in the tubular fluid.
  - C. A potential hazard with systemic mannitol administration is a circulatory volume expansion.
  - D. The loop diuretics work by inhibiting the active transport of sodium chloride from the ascending limb of the loop of Henle.
71. Which of the following statements is true?
- A. The diameter of a platelet is usually 10-15 microns.
  - B. The usual diameter of an erythrocyte is 0.25 microns.
  - C. The usual thickness of an erythrocyte is 0.25 microns.
  - D. The molecular weight of hemoglobin is 32,236.
  - E. The ratio of leukocytes to erythrocytes in normal blood is 1:600.
72. Which of the following events does not occur during the vascular spasm phase of hemostasis?
- A. Edema
  - B. Shunting
  - C. Sequestering
  - D. Chemotaxis
73. Which of the following decrease blood viscosity?
- A. decreased blood temperature
  - B. decreased hematocrit, increased blood temperature
  - C. decreased blood temperature, increased hematocrit
  - D. increased hematocrit
74. Under normal physiological conditions, which organ has the lowest oxygen consumption per unit weight?
- A. brain
  - B. kidney
  - C. lungs
  - D. liver
75. Under normal resting conditions, the kidneys receive about what percentage of the cardiac output?
- A. 5%
  - B. 15%
  - C. 25%
  - D. 35%
76. Which of the following will increase pulmonary vascular resistance?
- A. fentanyl
  - B. alkalosis
  - C. 100% FiO<sub>2</sub>
  - D. hypoventilation

77. Choose the most correct statement.
- A. When viscosity increases, the Reynold's number increases.
  - B. Laminar flows occur with Reynold's numbers of greater than 3000.
  - C. If the vessel radius increases, the Reynold's number increases.
  - D. If the velocity of flow increases, the Reynold's number decreases.

78. Each hemoglobin molecule may carry \_\_\_ molecules of oxygen.

A. one

B. 1.34

C. four

D. eight

79. Thrombin added to a plasma sample will form fibrin within 10 seconds in all but which of the following circumstances?

A. functionally active fibrinogen is present.

B. heparin is absent.

C. fibrin degradation products are absent.

D. AT-III is present.

80. The therapy for hyperfibrinolysis is the administration of , which inhibits fibrinolysis.

A. heparin

B. protamine

C. coumarine

D. amicar

81. What is the average pulmonary resistance in a healthy adult?

A. 25 - 75 dynes\*sec/cm<sup>5</sup>

B. 100 - 250 dynes\*sec/cm<sup>5</sup>

C. 350 - 500 dynes\*sec/cm<sup>5</sup>

D. 600 - 750 dynes\*sec/cm<sup>5</sup>

82. Choose the most correct answer.

A. A left-to-right shunt will cause a child's arterial saturation to be desaturated when compared to normal values.

B. Peripheral cyanosis is a sympathetic response characterized by blue extremities and is associated with a normal PaO<sub>2</sub>.

C. In reference to oxygenators, a wettable surface is more traumatic than a non-wettable one.

D. A neonate presenting with a blue Tetralogy of Fallot is a non- surgical candidate.

83. If a patient presents with an oxygen consumption of 275 mL O<sub>2</sub>/min, a BSA of 1.8 m<sup>2</sup>, a PaO<sub>2</sub> of 120, a PvO<sub>2</sub> of 60, an SaO<sub>2</sub> of 95%, an SvO<sub>2</sub> of 70%, and a Hgb of 15 gms, what is the Cardiac Index?
- A. 1.9 mL/min
  - B. 2.2 L/min
  - C. 2.4 L/min/m<sup>2</sup>
  - D. 2.9 L/min/m<sup>2</sup>
84. Which of the following represents the correct order of the four hemostatic processes?
- A. platelet plug, vascular spasm, coagulation cascade, fibrin clot
  - B. contact, adhesion, spreading, aggregation
  - C. coagulation cascade, fibrin formation, fibrin clot, hemostasis
  - D. vascular spasm, platelet plug, coagulation cascade, fibrin clot
85. Choose the incorrect statement.
- A. Catecholamines, glucagon, growth hormone, and cortisol are all detrimental to insulin levels.
  - B. Dehydration is a great danger to patients with ketosis because of their hyperglycemic state.
  - C. Insulin deficiency is responsible for a decrease in lipolysis followed by a decrease in the levels of glucose (decreased gluconeogenesis).
  - D. Gluconeogenesis is the process by which the liver catabolize non- carbohydrates into glucose.
86. Which of the following coagulation factors require a fat-soluble vitamin to function properly in the coagulation cascade?
- A. Factors II, V, VII, and IX
  - B. Factors II, VII, IX, and X
  - C. Factors V, VII, IX, and X
  - D. Factors VII, IX, X, and XIII
87. The temperature control center of the body is located in the
- A. subdural region.
  - B. brain stem.
  - C. anterior hypothalamus.
  - D. posterior pituitary.
88. Which of the following is true concerning the P wave of the ECG?
- A. During the P wave, ventricular depolarization occurs.
  - B. During the P wave, the atrioventricular valves are open.
  - C. During the P wave, the ventricles are undergoing isovolumetric contraction.
  - D. During the P wave, atrial repolarization occurs.

89. Clotting factors are produced in the \_\_\_\_\_ and normally circulate through the body in an \_\_\_\_\_ form.
- adrenal glands, active
  - liver, inactive
  - lungs, inactive
  - pituitary gland, active
90. Another term for the antidiuretic hormone (ADH) is
- furosemide.
  - angiotensin II.
  - vasopressin.
  - renin.
91. Choose the most correct statement.
- Cerebral oxygen consumption is increased with CPB.
  - The pH-stat method of blood gas control on CPB reduces the non- temperature corrected CO<sub>2</sub>, which produces a lower cerebral blood flow compared to values observed when using the alpha-stat method.
  - The use of an arterial line filter in the CPB circuit may improve neurological outcomes following surgery.
  - Neuropsychological deficits are rare following myocardial revascularization.
92. The correct definition of cor pulmonale is:
- dual chamber LA
  - LV hypertrophy
  - pulmonary hypertension
  - atretic pulmonary valve
93. As blood temperature decreases,
- O<sub>2</sub> gas solubility decreases.
  - CO<sub>2</sub> and O<sub>2</sub> gas solubility increase.
  - Less volume of CO<sub>2</sub> and O<sub>2</sub> gas may be dissolved in blood at the same partial pressures.
  - CO<sub>2</sub> gas solubility decreases.
94. Which of the following statements is the most correct?
- The A-V capillary beds of the skin dilate to conserve heat when the blood and body are cold.
  - The cerebral vasculature is under a high degree of control by sympathetic nerves.
  - Both the hepatic artery and the hepatic vein provide blood flow to the liver.
  - The hepatic sinusoidal capillary endothelium prevents blood proteins from entering the extravascular space of the liver.
  - Hepatic venous system obstruction may be caused by an improper placement of the inferior vena caval cannula for CPB.

95. Choose the most correct statement from the following.
- A. A low gas-to-blood flow ratio during CPB may lead to a respiratory alkalosis.
  - B. As the CO<sub>2</sub> level in the ventilating gas provided to an oxygenator is decreased, the blood pH will also decrease.
  - C. Lower blood flows on CPB during rewarming may lead to a metabolic acidosis.
  - D. The hematocrit reduction of CPB, if excessive, may lead to a loss of bicarbonate.
96. The average cardiac index for a neonate with a BSA of 0.75 m<sup>2</sup> is
- A. 100 cc/min/m<sup>2</sup>.
  - B. 233 cc/min/m<sup>2</sup>.
  - C. 366 cc/min/m<sup>2</sup>.
  - D. 500 cc/min/m<sup>2</sup>.
97. Choose the most incorrect statement.
- A. Heparin must be used in veno-venous bypass systems while supporting the circulation in all liver transplantation surgeries.
  - B. Cyclosporin therapy in organ transplantation patients decreases the function of T-helper lymphocytes, which inhibits the actions of the immune system.
  - C. During liver transplantation, the use of an extracorporeal shunt enables a stable venous return and assures decompression of the lower caval and portal venous systems.
  - D. Liver transplant patients may benefit from the use of an intraoperative rapid infusion system.
98. Heparin must combine with \_\_\_\_\_ to be physiologically effective.
- A. Thrombin
  - B. Factor X
  - C. Prothrombin
  - D. Fibrinogen
  - E. Antithrombin III
99. Which of the following aortic cannula sizes would be most appropriate for a 9 kg child undergoing cardiopulmonary bypass for correction of a ventricular septal defect?
- A. 10 Fr
  - B. 12 Fr
  - C. 16 Fr
  - D. 18 Fr

100. Which of the following is not true of prostacyclin (PGI<sub>2</sub>) use in conjunction with CPB?
- A. The purpose of its use is to inhibit platelet aggregation.
  - B. Use of PGI<sub>2</sub> may produce significant hypertension.
  - C. PGI<sub>2</sub>'s short half-life allows rapid return of platelet function upon cessation of treatment.
  - D. Glomerular filtration is increased through its vasodilating effects.
101. Choose the incorrect statement.
- A. During hypothermic CPB, the use of the pH-stat clinical management technique involves the temperature correction of all blood gas values to the actual body temperature of a patient.
  - B. If a perfusionist uses the pH-stat method for blood gas regulation during hypothermic CPB, it is likely that the sweep gas flow rate will be decreased below that utilized during normothermia (assume a membrane oxygenator is in use).
  - C. The alpha-stat method uses 37°C blood gas results, or uncorrected results, for actual blood gas determinations during hypothermic CPB.
  - D. The alpha-stat method often requires the addition of CO<sub>2</sub> to maintain appropriate blood gas levels, which may also produce the "luxuriant perfusion" phenomenon.
102. A normal left atrial pressure is expressed by which of the following?
- A. 2 mm Hg
  - B. 7 mmHg
  - C. 24 mmHg
  - D. 90 mmHg
103. The effectiveness of a depth filter is dependent upon all of the following except the
- A. number of microemboli exposed.
  - B. adsorption character.
  - C. length and turbulence of the blood path.
  - D. pore size of the filter medium.
104. Choose the incorrect statement.
- A. A higher gas-to-blood flow ratio during CPB may lead to respiratory acidosis.
  - B. Higher CO<sub>2</sub> levels in the ventilating gas delivered to an oxygenator may lead to a lower blood pH.
  - C. Lower blood flows on CPB during rewarming may lead to metabolic acidosis.
  - D. The hematocrit reduction of CPB, if excessive, may lead to a loss of bicarbonate.

105. When terminating CPB following a mitral valve replacement, PA pressures should be maintained
- A. near preoperative values.
  - B. lower than preoperative values.
  - C. higher than preoperative values.
  - D. at any reasonable value (makes no difference).
106. The alpha-stat method most closely matches the characteristics of
- A. poikilotherms.
  - B. hibernators.
  - C. mammals.
  - D. homeotherms.
107. Centrifugal pumps depend on all of the following technologies except
- A. positive displacement.
  - B. rotational acceleration.
  - C. afterload.
  - D. preload.
108. Choose the most correct statement.
- A. Normally, hemoglobin is 27% saturated at a plasma pO<sub>2</sub> of 50 mmHg; this is defined as the P<sub>50</sub> of blood.
  - B. If the P<sub>50</sub> of blood rises, this is an indication of right-shifting of the oxyhemoglobin saturation curve; this means that oxygen is more tightly bound to the hemoglobin molecule.
  - C. As the pH of the blood falls, the oxyhemoglobin curve would shift to the right and the P<sub>50</sub> would fall.
  - D. As the tissue temperature falls with hypothermic CPB, a rightward shift of the oxyhemoglobin dissociation curve occurs and oxygen is released.
109. If abnormally increased vent return and decreased systemic pressure are evident while on total CPB (with the tapes down), what may be present?
- A. PDA
  - B. coarctation of the aorta
  - C. ASD
  - D. VSD
110. During CPB, the blood flow is 4500 mL/min, the SaO<sub>2</sub> is 97%, the SvO<sub>2</sub> is 78%, and the hemoglobin concentration is 7.5 g%. Disregarding the effect of PO<sub>2</sub>, determine the A-V O<sub>2</sub> content difference.
- A. 0.5 vol%
  - B. 1.9 vol%
  - C. 4.0 vol%
  - D. 12.8 vol%

111. If a child on ECMO begins to exhibit pulmonary improvement, assuming reasonable cardiac function and no change in ventilator settings, the PaO<sub>2</sub> of the child's airway would be expected to
- fall.
  - stay the same.
  - increase.
  - change erratically.
112. A decrease in temperature and 2,3 DPG will cause the oxyhemoglobin dissociation curve to
- shift leftward.
  - shift rightward.
  - shift upward.
  - remain unchanged.
113. The units for body surface area are most correctly expressed as\_\_\_\_\_.
- cc
  - m
  - m<sup>2</sup>
  - cc<sup>2</sup>
114. Gravitational venous return
- generally requires a height differential of approximately 25-30 cm.
  - offers greater control over fluid balance than does pump venous return.
  - is mandatory in left heart bypass.
  - is desirable only while on partial bypass.
115. When employing femoral arterial cannulation for blood reentry to the patient during CPB,
- the femoral artery cannula tip is aimed toward the head and the flow is antegrade in the descending aorta.
  - it is not as important to monitor arterial line pressure as it is with traditional ascending aortic cannulation.
  - blood flow is retrograde in the descending aorta and blood flow to the cannulated limb is compromised.
  - is associated with a lower incidence of arterial dissection than traditional ascending aortic cannulation.
116. Which of the following is a false statement?
- Particulate contamination of cardioplegia produces a strong vasodilatory effect.
  - Calcium antagonists in some cardioplegia have been shown to improve myocardial protection, especially at normothermia.
  - Procaine may effectively be used in crystalloid cardioplegia.
  - It is recommended that an 8 micron filter be used with crystalloid cardioplegia.

117. At 30°C, a patient is considered to be in which level of hypothermia?
- mild
  - moderate
  - deep
  - profound
118. A large bolus of nitroglycerin given during cardiopulmonary bypass would probably
- increase the mean arterial blood pressure of the patient.
  - increase the venous reservoir volume.
  - increase the central venous pressure.
  - decrease the venous reservoir volume.
119. Choose the incorrect statement.
- Pulsatile flow has been proven to increase hemolysis, platelet destruction, and coagulopathies.
  - The ph-stat method requires the pCO<sub>2</sub> to be increased during hypothermia in order to maintain a normal pH.
  - A decreased pH (acidosis) shifts the oxyhemoglobin dissociation curve to the right, resulting in lower oxygen affinity to hemoglobin at the same partial pressure.
  - Centrifugal pumps will not overpressurize CPB lines because they are both preload and afterload dependent.
120. During rapid bloodstream cooling for hypothermia while on CPB,
- a 10 degree Celsius temperature gradient must be observed between the water inlet and the venous blood temperature.
  - a patient's O<sub>2</sub> requirement at 28 degrees Celsius is about 1/4 of that at normothermia.
  - the CO<sub>2</sub> gas solubility increases, the vascular resistance most likely increases, and metabolic acidosis may begin.
  - the vascular resistance most likely decreases as CPB proceeds.

1. B,C,B,C,A,B,D,D,C,B,A,A,B,D,A,A,D,A,A,B

21. C,D,B,B,C,A,A,C,D,D,C,B,A,C,A,A,D,B,D,C

41. C,D,D,E,C,B,D,E,D,C,C,B,C,A,C,D,A,D,A,C

61. D,A,D,C,A,A,C,C,C,C,E,C,B,B,B,D,C,C,D,D

81. B,B,D,D,C,B,C,B,B,C,C,C,B,E,C,B,A,E,B,B

101. D,B,D,A,A,A,A,C,A,B,A,A,C,A,C,A,B,D,A,C

**SAMPLE TEST 2**

1. Which of the following normally has the lowest blood pO<sub>2</sub>?
  - A. fetal ascending aorta
  - B. umbilical artery
  - C. maternal artery
  - D. umbilical vein
  
2. Closure of the small valve that overlies the foramen ovale in the \_\_\_\_ (A-atrial, V-ventricular) septum is associated with \_\_\_\_ ( I-increased or D-decreased,) right chamber pressure.
  - A. V,I
  - B. A,I
  - C. V,D
  - D. A,D
  
3. What is the name of the subclavian to PA anastomosis?
  - A. Ebstein shunt
  - B. Glenn shunt
  - C. Blalock - Taussig
  - D. Blalock - Hanlon
  
4. Which of the following are considered atrioventricular valves?
  - A. aortic and pulmonary
  - B. aortic and tricuspid
  - C. mitral and pulmonary
  - D. mitral and tricuspid
  
5. The pericardium overlaps all of the following except the:
  - A. aorta
  - B. coronary sinus
  - C. PA
  - D. SVC
  
6. Correctly complete the following sentence. The coronary sinus
  - A. is actually an extension of the vein of Marshall.
  - B. lies on the anterior surface of the heart.
  - C. empties into the superior portion of the right atrium.
  - D. lies in an interventricular sulcus.
  
7. During congenital intracardiac surgery, excessive venous blood draining into the right atrium may indicate the presence of a/an:
  - A. patent ductus arteriosus
  - B. patent foramen ovale
  - C. anomalous pulmonary venous return
  - D. persistent left superior vena cava

8. The majority of the population is their coronary \_\_\_\_\_ dominant with respect to artery system.
- A. right
  - B. superior
  - C. balanced (non-dominant)
  - D. left
9. What is the effect of vagal stimulation?
- A. decreased heart rate
  - B. increased systolic pressure
  - C. increased heart rate
  - D. increased coronary filling
10. The pulmonary veins empty into the:
- A. right atrium
  - B. left ventricle
  - C. right ventricle
  - D. left atrium
11. Which of the following statements is true?
- A. Cardiac venous blood drains either into the coronary sinus or directly into the right atrium.
  - B. Metarterioles and arteriovenous anastomosis both circumvent the capillary beds.
  - C. The major blood supply of the septum is the circumflex artery.
  - D. The SA nodal branch of the RCA is almost always responsible for the blood supply to the SA node.
12. Treatment for a blood transfusion reaction should include which of the following modalities?
- A. administration of steroids, diuretics, and heparin
  - B. administration of benzodiazepines, nitroprusside, and hydroxyethylstarch solution
  - C. administration of platelets, fresh frozen plasma, and cryoprecipitate
  - D. administration of vasopressors, antibiotics, and cryoprecipitate
13. Of the following blood vessels, which is not found in the circle of Willis?
- A. right posterior communicating artery
  - B. basilar artery
  - C. left middle cerebral artery
  - D. anterior communicating artery
14. The Tetralogy of Fallot consists of which of the following features?
- A. ASD
  - B. pulmonary stenosis
  - C. right-to-left shunt
  - D. aortic coarctation

15. Which defect is responsible for 25% of cardiac deaths during the first month of life?
- A. transposition of the great vessels
  - B. HLHS
  - C. double outlet RV
  - D. VSD
16. In adults, the most common congenital defect is the:
- A. aortopulmonary window
  - B. patent ductus
  - C. ventricular septal defect
  - D. atrial septal defect
17. Which of the following may be associated with Tetralogy of Fallot?
- A. IHSS
  - B. Pulmonary atresia
  - C. Vascular rings
  - D. ASD
18. In pulmonary stenosis, the \_\_\_\_\_ becomes hypertrophied in its attempt to eject its blood content through the valve opening.
- A. left ventricle
  - B. left atrium
  - C. right atrium
  - D. right ventricle
19. The treatment for an antithrombin III deficiency is:
- A. cryoprecipitate
  - B. platelet concentrate
  - C. packed red cells
  - D. fresh frozen plasma
20. The Glenn Procedure creates a shunt between the:
- A. LA and RA
  - B. aorta and main PA
  - C. SVC and right PA
  - D. aorta and right PA
  - E. aorta and left PA
21. An isolated ventricular septal defect without other cardiac pathology:
- A. causes increased right ventricular work load
  - B. never closes spontaneously
  - C. may be repaired without cardiopulmonary bypass
  - D. is usually associated with cyanosis in the first month of life

22. Which of the following is a true statement?
- A. The leaflets of the atrioventricular valves are thinner than the outflow tract valves.
  - B. The left atrioventricular valve is tricuspid.
  - C. Lunulae are found on the cusps of semilunar valves.
  - D. The papillary tissue into which the chordae tendinae insert are non-contractile in nature.
23. The Ostium Primum defect is located where on the atrial septum?
- A. near the tricuspid valve
  - B. superior to the foramen ovale
  - C. near the pulmonary semilunar valve
  - D. in the mid portion of the septum
24. Choose the incorrect statement.
- A. The hepatic veins are located superior to the renal veins.
  - B. The inferior vena cava has a rudimentary valve which extends upward on the septum from the opening.
  - C. The papillary muscle complex of the semilunar valves consists of the cusp, chordae tendinae, and papillary muscle.
  - D. The anterior spinal artery is responsible for a greater percentage of blood flow to the spinal column than the posterior spinal arteries.
25. A Pott's operation is an anastomosis of the:
- A. ascending aorta to the subclavian artery
  - B. ascending aorta to the left pulmonary artery
  - C. descending aorta to the pulmonary artery branch
  - D. subclavian artery to the pulmonary artery branch
26. Which of the following is not a form of pulmonary stenosis?
- A. infundibular
  - B. peripheral
  - C. ventricular
  - D. valvular
27. The aortic sinus is also known as the:
- A. sinus transversus
  - B. sinus coronaries
  - C. sinus vinarum
  - D. sinus of valsalva
28. Venous return to the right atrium is not supplied by the:
- A. Pulmonary vein
  - B. Inferior vena cava
  - C. Coronary sinus
  - D. Superior vena cava

29. Of the following arteries, which is most superior?
- A. Iliac Mesenteric
  - B. Celiac Renal
  - C.
  - D.
30. The loose fitting sac surrounding the heart is the:
- A. pericardium
  - B. epicardium
  - C. endocardium
  - D. myocardium
31. Heparin's primary effect is to:
- A. inhibit factor VIII
  - B. inhibit plasminogen to plasmin
  - C. kallikrein
  - D. accelerate AT-III binding to thrombin
32. The action of arfonad is which of the following?
- A. increases cardiac output
  - B. liberates acetylcholine
  - C. blocks transmission in the autonomic ganglia
  - D. causes vasoconstriction
33. Atropine and Scopolamine administration might result in which of the following?
- A. Increased heart rate
  - B. Increased secretions
  - C. Vagal stimulation
  - D. No sedative effects
34. All of the following are antihypertensives except:
- A. epinephrine phenylephrine
  - B. amphetamine nitroglycerine
  - C.
  - D.
35. The Partial Thromboplastin Time (PTT) measures the \_\_\_\_\_ portion(s) of the coagulation cascade.
- A. common
  - B. intrinsic
  - C. intrinsic and common
  - D. extrinsic
  - E. extrinsic and common

36. The treatment for malignant hyperthermia is:
- A. slow topical cooling
  - B. dantrolene sodium
  - C. digitalis
  - D. halothane
37. Thrombin time is an indication of which process?
- A. activation of Factor VII
  - B. conversion of fibrinogen to fibrin
  - C. conversion of plasminogen to plasmin
  - D. conversion of fibrin to fibrinogen
38. The primary effect of dobutamine is to
- A. increase blood pressure.
  - B. increase heart rate.
  - C. cause peripheral vasoconstriction.
  - D. increase cardiac output.
39. Which of the following statements is not true of protamine?
- A. Protamine binds directly to AT-III.
  - B. Protamine is derived from salmon sperm.
  - C. Protamine has a shorter half-life than heparin.
  - D. Protamine is an inorganic base.
40. Atropine is used to:
- A. increase urine output
  - B. relax muscles
  - C. relieve preoperative anxiety
  - D. treat bradycardia
  - E. treat tachycardia
41. Which of the following statements is not true regarding heparin?
- A. Bovine lung heparin is more antigenic than porcine gut heparin.
  - B. Heparin directly inhibits the liberation of thromboplastin from circulating platelets.
  - C. Heparin is strongly acidic.
  - D. Heparin directly inhibits clotting factors IX, X, XI, and XII.
42. When compared to normal serum osmolality, a cardioplegic solution exhibiting an osmolality of 330 milliosmols (mOsm) is
- A. 20% higher.
  - B. 10% higher.
  - C. within normal range.
  - D. 20% lower.

43. Which of the following drugs would most likely be associated with the inhibition of prothrombin synthesis?
- A. Coumadin
  - B. Persantine
  - C. Heparin
  - D. Amicar
  - E. CPDA-1
44. The main manufacturer of PGE1 during fetal circulation is (are) the
- A. area around the PDA.
  - B. placenta.
  - C. endocrine glands.
  - D. lungs.
45. Which of the following is not a steroid?
- A. Prednisone
  - B. Decadron
  - C. Solu-medrol
  - D. Tris-hydroxymethyl aminomethane
46. A higher incidence of anaphylactoid reactions to protamine occurs in patients who have a history of
- A. previous coronary artery bypass surgery, cold agglutinins, or Humulin allergy.
  - B. heparin therapy, coumadin therapy, or liver disease.
  - C. vasectomy, NPH insulin use, or fish allergies.
  - D. hysterectomy, estrogen therapy, or egg allergies.
47. In a low dose protocol, Dopamine is primarily:
- A. alpha and beta adrenergic
  - B. alpha adrenergic
  - C. dopaminergic
  - D. beta adrenergic
48. Which of the following is not true about an alpha adrenergic drug?
- A. increases available energy
  - B. decreases afterload
  - C. stimulates vascular constriction
  - D. elicits excitatory response
49. Which of the following tests is commonly performed and closely monitored in patients who have an artificial valve?
- A. PT
  - B. ACT
  - C. TT
  - D. PTT

50. Which of the following statements is not true?
- A. The use of phentolamine would result in hypotension.
  - B. Alpha receptors are found mostly in smooth muscle.
  - C. An alpha-blocker causes vasoconstriction.
  - D. Beta stimulation causes vasodilation.
51. The enzyme of the body responsible for uptake of the parasympathetic neuroeffector is:
- A. carbonic anhydrase
  - B. acetylcholinesterase
  - C. COMT
  - D. MAO
52. ACh is not found where?
- A. dopaminic receptors
  - B. preganglia
  - C. muscarinic receptors
  - D. nicotinic receptors
53. Antiemetic drugs treat which of the following conditions?
- A. fever
  - B. renal shutdown
  - C. pain
  - D. vomiting
  - E. bleeding
54. In low dosages, epinephrine is
- A. used to increase the glomerular filtration rate.
  - B. vasodilatory.
  - C. alpha stimulatory.
  - D. beta stimulatory.
55. The major complications of Thiazide diuretic therapy are related to its renal effects and include all of the following except:
- A. hypovolemia
  - B. metabolic acidosis
  - C. decreased GFR
  - D. hypokalemia
56. Dopamine Hydrochloride (Intropin) is sometimes used in conjunction with sodium nitroprusside (Nipride) to
- A. treat severe episodes of sinus tachycardia.
  - B. release calcium originally bound by citrate.
  - C. decrease high potassium levels after cardioplegic infusions.
  - D. improve myocardial function curves in the immediate postoperative phase.

57. Which of the following statements is true regarding heparin?
- A. Heparin dissolves existing clots.
  - B. Heparin stimulates the action of factors IX and XI.
  - C. Heparin stimulates antithrombin III activation.
  - D. Heparin has a half-life of approximately 2 hours since it is readily absorbed in the gastrointestinal tract.
58. A rise in cardiac output due to an increase in coronary perfusion is a secondary effect of which of the following drugs?
- A. norepinephrine
  - B. neosynephrine
  - C. amrinone
  - D. adrenaline
59. Which of the following is a true statement?
- A. Hypocalcemia is usually a result of Edecrine treatment.
  - B. The small molecular size of Mannitol makes it an effective diuretic.
  - C. Potassium replacement is usually necessary with the use of Lasix.
  - D. Reabsorption of  $\text{Na}^+$  and  $\text{Cl}^-$  in the ascending loop of Henle, proximal tubule, and distal tubule is promoted by Furosemide.
60. The action of procainamide is:
- A. antiemesis
  - B. antidiuresis
  - C. anticoagulation
  - D. the same as quinidine
61. Which of the following groups contains all of the vascular shunts?
- A. Placenta Arteriosus, Atrial Septal Shunt, Patent Ductus Arteriosus, Placenta Venosus
  - B. Patent Foramen Ovale, Thebesian Ovale, Patent Ductus Arteriosus, Ductus Ovale
  - C. Patent Foramen Ovale, Patent Ductus Arteriosus, Placenta, Ductus Venosus
  - D. Placenta Arteriosus, Ductus Ovale, Placenta Venosus, Patent Ductus Arteriosus
62. Which of the following statements is not true?
- A. Ventricular wall thickness is a direct characteristic of wall compliance.
  - B. Platelet activation by cellular contact is prohibited by the release of  $\text{PGI}_2$  from endothelial cells.
  - C. Heparin prevents platelet activation upon exposure of blood to non-cellular surfaces.
  - D. Surface-coating with albumin reduces platelet adhesion.

63. Calculate the  $pO_2$ , given an atmospheric pressure of 740 mmHg and a % $O_2$  of 21.
- A. 160 mmHg
  - B. 240 mmHg
  - C. 155 mmHg
  - D. 120 mmHg
64. What is the most common extracellular anion?
- A.  $PO_4$
  - B. Cl
  - C. Na
  - D. K
65. Choose the most correct statement.
- A. Organ vascular resistance is directly proportional to vessel length and blood viscosity.
  - B. Viscosity is defined as the shear rate divided by the shear stress.
  - C. The pressure gradient across either a vascular bed or a length of arterial CPB tubing is inversely proportional to blood flow.
  - D. The perfusion provided to an organ is directly proportional to the driving pressure, the vascular radius, and the viscosity of blood.
66. Which of the following does not contribute to the ability of a neonatal heart to withstand longer ischemic periods?
- A. increased glycogen stores
  - B. relatively high amount of collagen in the myocardium
  - C. higher ability to produce ATP through glycolysis
  - D. lower metabolic rate
67. Which of the following is true of type O blood?
- A. RBC's have A and B antigen.
  - B. Plasma has no A or B antibodies.
  - C. RBC's have no A or B antibodies.
  - D. Plasma has O antigen.
68. Select the incorrect statement.
- A. A rise in plasma volume following a fall in ADH concentration in the circulating blood is common.
  - B. An increase in blood volume will decrease the secretion of ADH.
  - C. In the absence of ADH, most of the fluid entering the collecting ducts appears in the urine.
  - D. Secretion of hydrogen ions into the renal tubules helps regulate the acidity of the extracellular fluids of the body.
  - E. During alkalemia, bicarbonate reabsorption by the kidney is decreased.

69. Pressure has which relationship to vessel length?
- A. indirect
  - B. direct
  - C. length raised to the fourth power
  - D. length does not matter
70. The Prothrombin Time (PT) is a measurement of what function?
- A. intrinsic time
  - B. extrinsic time and common pathway
  - C. extrinsic time
  - D. intrinsic time and common pathway
71. What is the major determinant of cerebral blood flow?
- A. aortic pressure
  - B. cardiac output
  - C.  $p\text{CO}_2$
  - D.  $p\text{O}_2$
72. What is the normal renal fraction of cardiac output?
- A. 20%
  - B. 32%
  - C. 5%
  - D. 12%
73. Most potassium is found in which body compartment?
- A. extracellular
  - B. intracellular
  - C. intravascular
  - D. interstitial
74. Which law states that the wall tension of a vessel resistant to pressure is equal to the vessel radius multiplied by the transmural pressure?
- A. Gay-Lussac's Law
  - B. Boyle's Law
  - C. Starling's Law
  - D. La Place's Law
75. Which of the following is true concerning the P wave of the ECG?
- A. During the P wave, the atrioventricular valves are open.
  - B. During the P wave, ventricular depolarization occurs.
  - C. During the P wave, atrial repolarization occurs.
  - D. During the P wave, the ventricles are undergoing isovolumetric contraction.

76. Thromboxane is synthesized in the \_\_\_\_\_ and \_\_\_\_\_ ADP release.
- A. endothelial cells, decreases
  - B. platelet membrane, increases
  - C. endothelial cells, increases
  - D. tissue membrane, decreases
77. The least relevant preoperative evaluation for a pediatric patient with CHD is:
- A. general appearance, color, and activity
  - B. ECG
  - C. heart sounds
  - D. chest x-ray
78. Which of the following statements is true?
- A. The usual thickness of an erythrocyte is 0.25 microns.
  - B. The ratio of leukocytes to erythrocytes in normal blood is 1:600.
  - C. The usual diameter of an erythrocyte is 0.25 microns.
  - D. The molecular weight of hemoglobin is 32,236.
  - E. The diameter of a platelet is usually 10-15 microns.
79. Which of the following is not a criteria for a child to be placed on ECMO?
- A. reversible disease
  - B. patient weight greater than 2 kg
  - C. expected mortality less than 90%
  - D. on a ventilator less than 14 days
80. Hemoglobin is expressed in which of the following units?
- A. %
  - B. g of Hgb / 100 mL blood
  - C. % / kg
  - D. mg of Hgb / 100 cc blood
81. The macula densa is a group of cells located in
- A. the afferent arteriole.
  - B. the collecting ducta.
  - C. the distal tubule.
  - D. the proximal tubule.
82. Which of the following will not increase pulmonary blood flow afterbirth?
- A. removal of the placenta from fetal circulation
  - B. vascular smooth muscle dilatation as a result of high  $PO_2$
  - C. reabsorption of interstitial lung fluid through the lymphatic system
  - D. mechanical distention of the lungs with the first breath
  - E. closure of the ductus arteriosus

83. The relationship between stroke volume and end-diastolic volume is expressed by
- A. Marey's Law.
  - B. Starling's Law.
  - C. Boyle's Law.
  - D. the Borelli Principle.
84. Choose the correct statement.
- A. Mannitol is a loop diuretic.
  - B. Mannitol works to produce a diuresis by retaining water in the tubular fluid.
  - C. A potential hazard with systemic mannitol administration is a circulatory volume expansion.
  - D. The loop diuretics work by inhibiting the active transport of sodium chloride from the ascending limb of the loop of Henle.
85. Which statement is true?
- A. Decreased capillary permeability (capillary leakage) is most commonly associated with complement activation.
  - B. Alkalosis, hypotension, and a rise in blood lactate levels all result from hypoperfusion and shock.
  - C. Transposition of the great vessels is considered an acyanotic heart defect.
  - D. Neonates with a CHD who develop pulmonary hypertension are in a lethal state because, while their cardiac problems may be repaired, in the end the child will exhibit a high PVR which the RV can not pump against and will ultimately go into failure.
86. The temperature control center of the body is located in the
- A. subdural region.
  - B. anterior hypothalamus.
  - C. brain stem.
  - D. posterior pituitary.
87. Choose the incorrect statement.
- A. Catecholamines, glucagon, growth hormone, and cortisol are all detrimental to insulin levels.
  - B. Dehydration is a great danger to patients with ketosis because of their hyperglycemic state.
  - C. Insulin deficiency is responsible for a decrease in lipolysis followed by a decrease in the levels of glucose (decreased gluconeogenesis).
  - D. Gluconeogenesis is the process by which the liver catabolize non-carbohydrates into glucose.

88. Which of these would be the  $O_2$  content difference for the following patient:  $PaO_2 = 85$ ,  $SaO_2 = 97\%$ ,  $Hgb = 13$ ,  $PvO_2 = 50$ ,  $SvO_2 = 65\%$ ?
- A. 3.7 mL  $O_2$ /L
  - B. 5.7 mL  $O_2$ /kg
  - C. 5.7 vol%
  - D. 3.7 vol%
89. As blood temperature decreases,
- A.  $CO_2$  and  $O_2$  gas solubility increase.
  - B. Less volume of  $CO_2$  and  $O_2$  gas may be dissolved in blood at the same partial pressures.
  - C.  $CO_2$  gas solubility decreases.
  - D.  $O_2$  gas solubility decreases.
90. Each hemoglobin molecule may carry \_\_\_\_\_ molecules of oxygen.
- A. 1.34
  - B. four
  - C. eight
  - D. one
91. Choose the most correct statement.
- A. In children, the vasculature will accommodate greater flows with reduced systemic perfusion pressures as a result of a reduction in the elasticity of pediatric circulation.
  - B. In children, the vasculature has a reduced sensitivity to drugs.
  - C. The presence of hemoglobin F in children shifts the oxyhemoglobin dissociation curve in a manner to increase the  $P_{50}$ , which better transports oxygen to the tissues.
  - D. In children, third spacing of fluid is a greater problem during CPB because of their increased vascular permeability.
92. What is the resulting HCT of a mixture of 5 L of 45% HCT blood and 3 L of 25% HCT blood?
- A. 38
  - B. 28
  - C. 40
  - D. 33
93. During the aortic cross clamping period, myocardial energy requirements are influenced by all of the following except
- A. electromechanical activity.
  - B. myocardial temperature.
  - C. myocardial ATP levels.
  - D. ventricular wall tension.

94. The units for body surface area are most correctly expressed as \_\_\_\_\_.
- A. m
  - B. cc
  - C.  $m^2$
  - D.  $cc^2$
95. Which of the following would least influence the temperature of the myocardium?
- A. operating room ambient temperature
  - B. non-coronary collateral blood flow
  - C. esophageal, bladder, and rectal temperatures
  - D. pulmonary venous blood flow
  - E. operating room lighting
96. Cardiac index (CI) is expressed in units of
- A. Liters (L).
  - B.  $L/min^2$ .
  - C. L/min.
  - D.  $L/min/m^2$ .
97. Which of the following aortic cannula sizes would be most appropriate for a 9 kg child undergoing cardiopulmonary bypass for correction of a ventricular septal defect?
- A. 16 Fr
  - B. 10 Fr
  - C. 12 Fr
  - D. 18 Fr
98. Choose the most correct statement.
- A. Hypoventilation of a blood oxygenator during CPB may lead to a decrease in the ratio of bicarbonate ions to carbonic acid concentrations, and respiratory alkalosis will result.
  - B. With a decreased ventilation of the lungs, as in a chronic lung disease like emphysema, a respiratory alkalosis may result.
  - C. A high arterial blood carbon dioxide level in the blood exiting an oxygenator may be the result of a high carbon dioxide level in the venous blood at the oxygenator inlet.
  - D. The oxygen content of the hemoglobin and the bloodstream is a primary determinant of a respiratory acidosis or a respiratory alkalosis.
99. Bubble Point pressure may be increased by
- A. decreasing the pore diameter of the filter.
  - B. increasing the surface tension of the fluid.
  - C. decreasing the surface tension of the fluid.
  - D. increasing the pore diameter of the filter.
  - E. b and c.

100. The maximum rated blood flow of an oxygenator is known as the
- A. oxygen blood flow.
  - B. blood-gas transfer index.
  - C. reference blood flow.
  - D. hemolysis index.
101. Choose the most correct statement.
- A. The normal blood  $\text{HCO}_3$  concentration is 1.27 mEq/L.
  - B. One can estimate the carbonic acid concentration in blood by multiplying the blood partial pressure of carbon dioxide times 0.03.
  - C. Bicarbonate ion concentration in the blood is usually one twentieth that of the carbonic acid level.
  - D. Bicarbonate ion concentration in the blood assists in the diagnosis of respiratory acidosis or respiratory alkalosis.
102. When running a bubble oxygenator, a low venous oxygen saturation is an indication to
- A. increase the gas sweep.
  - B. increase the isoflurane percentage.
  - C. decrease the  $\text{FiO}_2$ .
  - D. increase the speed of the arterial pump head.
103. Which of the following is not true of platelet form and function during CPB?
- A. serotonin levels decrease
  - B. thromboxane levels increase
  - C. platelet counts fall rapidly
  - D. histamine levels increase
104. Centrifugal pumps depend on all of the following technologies except
- A. preload.
  - B. afterload.
  - C. rotational acceleration.
  - D. positive displacement.
105. Which of the following would not be considered for the perfusion of the pregnant patient?
- A. provision for fetal heart rate monitoring
  - B. incorporating a decreased prime volume
  - C. use of moderate or profound hypothermia
  - D. increasing the pump flow rate
  - E. scavenging of the potassium cardioplegia
106. Theoretically, "Warm Induction" cardioplegia
- A. preconditions the ventricle for longer subsequent periods of ischemia.
  - B. causes reperfusion injury.
  - C. is contraindicated in patients who have had recent ischemia.
  - D. is of no practical value.

107. Which of the following is used to treat hemoglobinuria?
- A. RBC's and  $\text{HCO}_3$
  - B. FFP and  $\text{HCO}_3$
  - C. Mannitol
  - D. Lasix
108. The average cardiac index for a neonate with a BSA of  $0.75 \text{ m}^2$  is
- A.  $100 \text{ cc/min/m}^2$ .
  - B.  $500 \text{ cc/min/m}^2$ .
  - C.  $366 \text{ cc/min/m}^2$ .
  - D.  $233 \text{ cc/min/m}^2$ .
109. Cardiac output (CO) is expressed in units of
- A.  $\text{L/min}^2$ .
  - B.  $\text{L/min/m}^2$ .
  - C. Liters (L).
  - D.  $\text{L/min}$ .
110. A large bolus of nitroglycerin given during cardiopulmonary bypass would probably
- A. decrease the venous reservoir volume.
  - B. increase the central venous pressure.
  - C. increase the mean arterial blood pressure of the patient.
  - D. increase the venous reservoir volume.
111. What is the approximate blood volume of a 9 lb. baby (assume  $85 \text{ mL/kg}$ )?
- A. 765 mL
  - B. 500 mL
  - C. 350 mL
  - D. 695 mL
112. Plasticizers, which leach out of PVC tubing, may do all but which of the following?
- A. cause massive hemolysis
  - B. discolor the tubing
  - C. produce an oily feeling on the tubing surface
  - D. increase red blood cell membrane stability
113. Circulating blood volume is calculated using which of the following values?
- A.  $0.8 \text{ L/kg} * \text{kg}$
  - B.  $0.08 \text{ L/kg} * \text{kg} * 1.34$
  - C.  $0.08 \text{ L/kg} * \text{kg} * \text{HCT}$
  - D.  $0.08 \text{ L/kg} * \text{kg}$

114. In order to reduce the complement activation associated with donorproducts, it is important to utilize all of the following except
- A. fresh blood products.
  - B. CPD depleted blood.
  - C. CMV negative blood.
  - D. leukocyte depleted blood.
115. IABP therapy has been suggested to increase coronary blood flow by
- A. providing the coronaries with an increased filling pressure duringdiastole.
  - B. decreasing the workload on the left ventricle.
  - C. decreasing the workload on the right ventricle.
  - D. providing the coronaries with an increased filling pressure duringsystole.
116. Which of the following tests provides an actual heparin level?
- A. ACT (Activated Clotting Time)
  - B. HPT (Heparin-Protamine Titration)
  - C. Sonoclot
  - D. HDR (Heparin Dose Response)
117. Choose the most incorrect statement.
- A. During liver transplantation, the use of an extracorporeal shunt enables a stable venous return and assures decompression of the lower caval and portal venous systems.
  - B. Cyclosporin therapy in organ transplantation patients decreases the function of T-helper lymphocytes, which inhibits the actions of the immune system.
  - C. Heparin must be used in veno-venous bypass systems while supporting the circulation in all liver transplantation surgeries.
  - D. Liver transplant patients may benefit from the use of an intraoperative rapid infusion system.
118. Choose the most correct statement.
- A. Myocardial energy stores may be theoretically maintained or enhanced with the infusion of cardioplegia solutions containing substrates.
  - B. Bicaval cannulation assists in maintaining adequate myocardial protection because of the technique's relative effectiveness of keeping the heart warm.
  - C. Mg<sup>++</sup> has never been used as a cardioplegic constituent chemical.
  - D. Substrates given during the administration of cardioplegia are just as beneficial when given cold as when they are given warm.
119. The effectiveness of a depth filter is dependent upon all of the following except the
- A. pore size of the filter medium.
  - B. length and turbulence of the blood path.
  - C. number of microemboli exposed.
  - D. adsorption character.

120. Which of the following is a false statement?
- A. Calcium antagonists in some cardioplegia have been shown to improve myocardial protection, especially at normothermia.
  - B. It is recommended that an 8 micron filter be used with crystalloid cardioplegia.
  - C. Procaine may effectively be used in crystalloid cardioplegia.
  - D. Particulate contamination of cardioplegia produces a strong vasodilatory effect.

1. B,D,C,D,B,A,D,A,A,D,A,A,B,B,B,D,D,D,D,C

21. A,C,A,C,B,C,D,A,C,A,D,C,A,D,C,B,B,D,A,D

41. A,B,A,B,D,C,C,B,A,C,B,A,D,D,B,D,C,B,C,D

61. C,C,C,B,A,D,C,A,B,B,C,A,B,D,A,B,B,B,C,B

81. C,E,B,C,D,B,C,C,A,B,D,A,C,C,A,D,C,C,E,C

101. B,D,A,D,C,A,A,D,D,A,C,D,D,B,A,B,C,A,A,D

**SAMPLE TEST 3**

1. The most common type of anomalous venous return is:
  - A. supracardiac
  - B. cardiac
  - C. infracardiac
  - D. cardiac
  
2. A Pott's operation is an anastomosis of the:
  - A. ascending aorta to the left pulmonary artery
  - B. descending aorta to the pulmonary artery branch
  - C. subclavian artery to the pulmonary artery branch
  - D. ascending aorta to the subclavian artery
  
3. The basic hemodynamic fault in a patent ductus arteriosus is a \_\_\_\_\_ shunt at the pulmonary artery level.
  - A. right, left
  - B. left, right
  - C. superior, inferior
  - D. inferior, superior
  
4. Which of the following statements is not true if viewing the heart through a median sternotomy?
  - A. The right atrioventricular sulcus may be seen.
  - B. The left atrium is predominant.
  - C. The apex points anteriorly.
  - D. The interventricular sulcus may be visualized.
  
5. The posterior hepatic vein connects to the
  - A. inferior vena cava.
  - B. hemiazygous system.
  - C. azygous system.
  - D. accessory-azygous system.
  
6. What is the most common type of valvular defect?
  - A. AI
  - B. AS
  - C. MI
  - D. MS
  
7. Which of the following is not evident in Tetralogy of Fallot?
  - A. VSD
  - B. pulmonary stenosis
  - C. ASD
  - D. overriding aorta
  - E. RV hypertrophy

8. Of the following arteries, which is most superior?
- A. Celiac
  - B. Mesenteric
  - C. Renal
  - D. Iliac
9. Where is the most common site for a coarctation of the aorta?
- A. ascending aorta distal to the coronary ostia
  - B. transverse aorta between the innominate and the carotid arteries
  - C. descending aorta distal to the subclavian artery
  - D. ascending aorta proximal to the innominate artery
10. Closure of the small valve that overlies the foramen ovale in the \_\_\_\_\_ (A-atrial, V-ventricular) septum is associated with \_\_\_\_ (D-decreased, I-increased) right chamber pressure.
- A. A,D
  - B. A,I
  - C. V,D
  - D. V,I
11. Which of the following statements is not true?
- A. Sinusoids are a type of capillary.
  - B. The intima of veins and arteries is continuous with the capillary endothelium.
  - C. The opening of a precapillary sphincter will force blood to flow through arteriovenous shunts.
  - D. The vaso-vasorum is the blood supply for the tunica adventitia of veins and arteries.
12. Which of the following statements is true?
- A. The SA nodal branch of the RCA is almost always responsible for the blood supply to the SA node.
  - B. The major blood supply of the septum is the circumflex artery.
  - C. Cardiac venous blood drains either into the coronary sinus or directly into the right atrium.
  - D. Metarterioles and arteriovenous anastomosis both circumvent the capillary beds.
13. Which of the following arteries would be found in the posterior interventricular sulcus?
- A. Posterior descending artery
  - B. Left circumflex
  - C. Acute marginal branch
  - D. Distal portion of the obtuse marginal branch

14. Pick the most correct statement:
- A. The Rastelli procedure is a cath lab technique in which a ballooncatheter is used to enlarge or create an ASD.
  - B. The Fontan operation facilitates complete correction of tricuspid atresia by placement of a tube graft conduit between the rightventricle and the pulmonary artery system.
  - C. A VSD is necessary for survival in a child born with tricuspid atresia.
  - D. A Blalock-Hanlon procedure creates an enlarged ASD and is done under cardiopulmonary bypass.
15. Which valve is commonly replaced with IHSS?
- A. tricuspid
  - B. pulmonary
  - C. mitral
  - D. aortic
16. The initiation of respiration in the newborn infant \_\_\_\_\_ pulmonary vascular resistance and \_\_\_\_\_ the pulmonary arterial pressure. (I-Increase, D-Decrease)
- A. I,I
  - B. I,D
  - C. D,I
  - D. D,D
17. In a Waterston-Cooley shunt you create a/an:
- A. VSD
  - B. aorta-pulmonary window
  - C. ASD
  - D. Subclavian to PA shunt
18. A PFO in a newborn can be categorized as what type of shunt?
- A. restrictive
  - B. non-restrictive
  - C. complex
  - D. cyanotic
19. Which of the following is a type III endocardial cushion defect?
- A. ostium primum defect
  - B. ostium primum defect with a cleft in the mitral and tricuspid leaflet
  - C. atrioventricular communis
  - D. sinus venosus
20. Which type of VSD is located between the pulmonary valve and the crista supraventricularis?
- A. Type I
  - B. Type II
  - C. Type III
  - D. Type IV

21. Regarding a VSD, which is correct?
- The type I defect is located in the muscular septum.
  - Early in life, the direction of shunt across a VSD (in the absence of other anomalies) will be right-to-left.
  - Cyanosis due to a right-to-left shunt across a VSD can occur when the pulmonary vascular resistance is high.
  - Membranous VSD's occur in the septum area near the apex of the left ventricle.
22. Choose the most correct statement:
- Truncus arteriosus results from an underdevelopment of the ventricular septum.
  - An ASD has a higher frequency of occurrence of cardiac malformation at birth than a VSD.
  - A VSD has a lower frequency of occurrence of cardiac malformation at birth than an ASD.
  - Pulmonary hypotension caused by any of several factors and leading to the development of right heart failure is known as cor pulmonale.
23. A loss of blood flow through the placenta at birth \_\_\_\_\_ the fetal systemic vascular resistance and \_\_\_\_\_ fetal aortic pressure. (I-increase, D-decrease)
- I,I
  - I,D
  - D,I
  - D,D
24. Excessive volume in the right atrium with bicaval cannulation and tapes down would indicate what?
- PFO
  - PDA
  - VSD with a right-to-left shunt
  - Persistent LSVC
25. Which of the following is a true statement?
- The left atrioventricular valve is tricuspid.
  - The leaflets of the atrioventricular valves are thinner than the outflow tract valves.
  - Lunulae are found on the cusps of semilunar valves.
  - The papillary tissue into which the chordae tendinae insert are non-contractile in nature.
26. Which of the following may be associated with Pentalogy of Fallot?
- ASD
  - IHSS
  - Pulmonary atresia
  - Vascular rings

27. Which of the following is not a true statement?
- A. All pulmonary blood returns to the left atrium.
  - B. Superficial bronchial veins precede pulmonary veins.
  - C. Deep bronchial veins precede pulmonary veins.
  - D. Some bronchial blood returns to the right heart.
28. What is the name of the subclavian to PA anastomosis?
- A. Blalock - Taussig
  - B. Blalock - Hanlon
  - C. Glenn shunt
  - D. Ebstein shunt
29. Under normal circumstances, the only bicuspid valve in the body is the:
- A. tricuspid
  - B. pulmonic
  - C. mitral
  - D. aortic
30. The Ostium Primum defect is located where on the atrial septum?
- A. near the tricuspid valve
  - B. in the mid portion of the septum
  - C. superior to the foramen ovale
  - D. near the pulmonary semilunar valve
31. Fill in the two missing steps of fetal development in correct order:
1. Development of Cardiac Tube
  2. Enlargement and Convolution of Cardiac Tube
  3. Enlargement and Convolution of Cardiac Tube
  4. Bifurcation of Truncus Arteriosus
  5. Bifurcation of Truncus Arteriosus
- A. (3) Ventricular wall enlargement; (5) Pulmonary maturation
  - B. (3) Pulmonary maturation; (5) Ventricular wall enlargement
  - C. (3) Development of Cardiac Valves; (5) Cardiac septation
  - D. (3) Cardiac septation; (5) Development of Cardiac Valves
32. During congenital intracardiac surgery, excessive venous blood draining into the right atrium may indicate the presence of a/an:
- A. patent ductus arteriosus
  - B. patent foramen ovale
  - C. persistent left superior vena cava
  - D. anomalous pulmonary venous return

33. In the case of a persistent left superior vena cava, which of the following statements is true?
- A. All venous blood returns through the superior vena cava.
  - B. Blood return from the right side of the body flows into the superior vena cava system.
  - C. Blood return from the left side of the body flows directly into the coronary sinus.
  - D. Blood return from the left side of the body flows directly into the right atrium.
34. The most common form of Total Anomalous Pulmonary Venous Return is:
- A. supracardiac
  - B. cardiac
  - C. infracardiac
  - D. extracardiac
35. Which of the following is true of the left atrium?
- A. The major blood return to the left atrium is through the bronchial veins.
  - B. The cardiac electrical impulse originates here in the SA node.
  - C. It is the most posterior chamber of the heart.
  - D. Left atrial blood passes to the right atrium through the fossa ovalis.
36. For Hypoplastic Left Heart Syndrome (HLHS), which statement is not true?
- A. The patient may have an atretic ascending aorta.
  - B. There may be no anatomic left ventricle.
  - C. The syndrome accounts for as many as 24% of the cardiac deaths in the first months of infancy.
  - D. The Mustard operation is the definitive surgical correction.
37. The Glenn Procedure creates a shunt between the:
- A. aorta and main PA
  - B. LA and RA
  - C. SVC and right PA
  - D. aorta and right PA
  - E. aorta and left PA
38. Which of the following is the proper order of aortic arch vessels (from proximal to distal)?
- A. R subclavian - R carotid - L innominate
  - B. R innominate - L common carotid - L subclavian
  - C. R internal carotid - L subclavian - L internal thoracic
  - D. R innominate - L subclavian - L common carotid

39. Which vessel does not drain into the right side of the heart?
- A. inferior vena cava
  - B. superior vena cava
  - C. azygous vein
  - D. bronchial vein
  - E. coronary sinus
40. The majority of the population is their coronary \_\_\_\_\_ dominant with respect to artery system.
- A. right
  - B. left
  - C. balanced (non-dominant)
  - D. superior
41. All of the following can be associated with aortic stenosis except:
- A. increased LA pressure
  - B. mitral insufficiency
  - C. increased aortic pressure
  - D. pulmonary congestion
42. Which defect is responsible for 25% of cardiac deaths during the first month of life?
- A. VSD
  - B. HLHS
  - C. transposition of the great vessels
  - D. double outlet RV
43. The Tetralogy of Fallot consists of which of the following features?
- A. pulmonary stenosis
  - B. ASD
  - C. aortic coarctation
  - D. right-to-left shunt
44. Which artery feeds the lower third of the spinal cord?
- A. anterior spinal artery
  - B. anterior communicating
  - C. anterior radicular artery
  - D. posterior intercostal
45. Venous return to the right atrium is not supplied by the:
- A. Inferior vena cava
  - B. Superior vena cava
  - C. Pulmonary vein
  - D. Coronary sinus

46. The vessels that directly communicate with the heart chambers are the:
- A. Thebesian vessels
  - B. azygous vessels
  - C. venules
  - D. arterioles
47. The aortic sinus is also known as the:
- A. sinus coronaries
  - B. sinus of valsalva
  - C. sinus vinarum
  - D. sinus transversus
48. A patient who is on MAO inhibition should be approached with caution when using all of the following drugs except
- A. Levophed
  - B. Norepinephrine
  - C. Epinephrine
  - D. Dobutamine
49. Which of the following is a true statement?
- A. The small molecular size of Mannitol makes it an effective diuretic.
  - B. Reabsorption of Na<sup>+</sup> and Cl<sup>-</sup> in the ascending loop of Henle, proximal tubule, and distal tubule is promoted by Furosemide.
  - C. Hypocalcemia is usually a result of Edecrine treatment.
  - D. Potassium replacement is usually necessary with the use of Lasix.
50. Which of the following statements is not true of protamine?
- A. Protamine has a shorter half-life than heparin.
  - B. Protamine is an inorganic base.
  - C. Protamine binds directly to AT-III.
  - D. Protamine is derived from salmon sperm.
51. Which of the following statements is not true regarding heparin?
- A. Heparin is strongly acidic.
  - B. Bovine lung heparin is more antigenic than porcine gut heparin.
  - C. Heparin directly inhibits clotting factors IX, X, XI, and XII.
  - D. Heparin directly inhibits the liberation of thromboplastin from circulating platelets.
52. Verapamil has actions similar to those of
- A. bretylium.
  - B. dilantin.
  - C. norpace.
  - D. nifedipine.

53. Which of the following is true?
- A. Another name for Norcuron is Pancuronium Bromide.
  - B. Aramine is known to have a vasoconstrictive effect on the coronaryarteries.
  - C. Inderal is used to increase the heart rate.
  - D. Innovar is a combination of sublimaze and inapsine.
  - E. Neostigmine is an anticholinesterase.
54. The drug of choice to treat hypertension during CPB of a pregnantpatient is:
- A. nitroglycerin
  - B. nitroprusside
  - C. hydrazaline
  - D. regitine
55. Which of the following is not an alternative to heparin utilization inconjunction with CPB?
- A. ancrod
  - B. protamine
  - C. hirudin
  - D. heparinoid
56. Lidocaine is used to treat:
- A. supraventricular arrhythmias
  - B. PAC's
  - C. ventricular fibrillation
  - D. atrial fibrillation
57. Malignant hyperthermia can be triggered by all of the following except:
- A. succinylcholine
  - B. halothane
  - C. isoflurane
  - D. enflurane
  - E. nitroprusside
58. Beta-2 stimulation is associated with:
- A. vasodilation
  - B. vasoconstriction
  - C. increased preload
  - D. increased heart rate
59. A rise in cardiac output due to an increase in coronary perfusion is asecondary effect of which of the following drugs?
- A. neosyneprine
  - B. adrenaline
  - C. norepineprine
  - D. amrinone

60. The main manufacturer of PGE1 during fetal circulation is (are) the
- A. lungs.
  - B. area around the PDA.
  - C. placenta.
  - D. endocrine glands.
61. Which of the following is not a choice for the induction of anesthesia in pediatrics?
- A. thiopental
  - B. ketamine
  - C. fentanyl
  - D. propranolol
62. Dopamine Hydrochloride (Intropin) is sometimes used in conjunction with sodium nitroprusside (Nipride) to
- A. decrease high potassium (K<sup>+</sup>) levels after cardioplegic infusions.
  - B. release Calcium (Ca<sup>++</sup>) originally bound by citrate.
  - C. improve myocardial function curves in the immediate postoperative stage.
  - D. treat severe episodes of sinus tachycardia.
63. Atropine and Scopolamine administration might result in which of the following?
- A. Increased heart rate
  - B. Increased secretions
  - C. No sedative effects
  - D. Vagal stimulation
64. Which of the following is not a reason why high-dose narcotics are utilized for analgesia?
- A. High-dose narcotics increase SVR or inhibit a rise in PVR for cyanotic lesions.
  - B. High-dose narcotics decrease myocardial O<sub>2</sub> demand with a negative inotropic effect for acyanotic lesions.
  - C. High-dose narcotics are rapidly eliminated in lungs.
  - D. High-dose narcotics are efficiently absorbed from subcutaneous, intramuscular, and mucosal sites.
65. Which of the following could be expected as a result of the administration of a calcium antagonist?
- A. Depletion of energy resources for mitochondrial activity
  - B. Systemic hypertension
  - C. Increase in PAP
  - D. Inhibition of Ca<sup>++</sup> into cardiac and vascular smooth muscle

66. A Protamine overdose may cause:
- A. arrhythmias
  - B. hypertension
  - C. excess bleeding
  - D. hypercoagulability
67. Which of the following drugs is considered to be a beta-adrenergic blocking agent?
- A. Inderal
  - B. Regitine
  - C. Heparin
  - D. Minipress
68. A common effect of beta-blocking agents is:
- A. positive inotropy
  - B. increased myocardial oxygen demand
  - C. antiarrhythmia
  - D. increased systolic pressures
69. Vasoconstriction caused by direct alpha-1 agonism would occur with which of the following drugs?
- A. dobutamine
  - B. epinephrine
  - C. phenylephrine
  - D. norepinephrine
70. The action of procainamide is:
- A. anticoagulation
  - B. antiemesis
  - C. the same as quinidine
  - D. antidiuresis
71. Dobutamine is known to
- A. liberate norepinephrine.
  - B. directly agonize beta-1 receptors.
  - C. cause bronchodilation.
  - D. interact adversely with dopamine.
72. Verapamil is used to treat
- A. ventricular tachycardia.
  - B. supraventricular tacharrhythmias.
  - C. hypotension.
  - D. hypertension.

73. What would be considered an average total ionized  $\text{Ca}^{++}$  level for a healthy adult?
- A. 2.0 mEq/dL
  - B. 5.0 mEq/L
  - C. 6.0 mEq/dL
  - D. 3.0 mEq/L
74. During total CPB, isuprel acts as a:
- A. vasodilator
  - B. positive inotrope
  - C. positive chronotrope
  - D. vasoconstrictor
75. Which of the following drugs originate in the Islets of Langerhan?
- A. Insulin
  - B. Vitamin K
  - C. Heparin
  - D. Norepinephrine
76. Which of the following, when administered intravenously, would not produce a reduction in arterial blood pressure?
- A. prazosin
  - B. vasoxyl
  - C. metoprolol
  - D. hydralazine
77. Which of the following drugs would probably not be considered for use in the treatment of an arterial blood pressure of 58/23 mmHg?
- A. Dopastat
  - B. Dobutrex
  - C. Ephedrine
  - D. Thorazine
78. Which of the following is not a steroid?
- A. Decadron
  - B. Tris-hydroxymethyl aminomethane
  - C. Prednisone
  - D. Solu-medrol
79. Low dose dopamine may be used to
- A. increase cardiac output.
  - B. increase renal blood flow.
  - C. increase preload.
  - D. decrease afterload.

80. Acetylcholine is generally recognized as a neurotransmitter at all but which of the following sites?
- A. Post-ganglionic parasympathetic nerve endings
  - B. Motor fiber terminals at neuromuscular junctions
  - C. Post-ganglionic sympathetic nerve endings
  - D. Autonomic ganglionic synapses
81. Thrombin time is an indication of which process?
- A. conversion of plasminogen to plasmin
  - B. activation of Factor VII
  - C. conversion of fibrin to fibrinogen
  - D. conversion of fibrinogen to fibrin
82. Which of the following effects would be expected with the administration of Propranolol Hydrochloride?
- A. decreased heart rate
  - B. increased cardiac contractility
  - C. increased cardiac output
  - D. antiemesis
83. Coumadin is:
- A. antagonized by vitamin K
  - B. appropriated by vitamin K
  - C. a short acting anticoagulant
  - D. commonly used with porcine valves
84. Prostaglandin E1 does not
- A. cause hypotension.
  - B. cause seizures.
  - C. produce apnea in infants.
  - D. decrease the rate of glomerular filtration.
85. The initial heparinizing dose for the average open heart patient is generally:
- A. 200-300 units/kg of body weight
  - B. 2-4 mg/lb of body weight
  - C. 0.3 cc per kilogram of body weight
  - D. 3 cc per kilogram of body weight
86. Which of the following drugs may be used to antagonize opioids?
- A. procardia
  - B. narcan
  - C. valium
  - D. diazepam

87. Pharmacodynamics is best defined as:
- A. The actions of an organism upon a given substance.
  - B. The elimination rate of a given substance from an organism.
  - C. The actions of a given substance upon an organism.
  - D. The method by which an organism distributes a given substance.
88. Which of the following is not a benzodiazepine?
- A. diazepam
  - B. valium
  - C. midazolam
  - D. tracrium
  - E. versed
89. A patient being weaned from CPB exhibits ventricular arrhythmias with a rate of 154 BPM. Which of the following drugs would probably be the drug of choice?
- A. Isuprel
  - B. Atropine
  - C. Vasoxyl
  - D. Lidocaine
90. All of the following cause vasodilation except:
- A. trimethaphan
  - B. apresoline
  - C. vasoxyl
  - D. arfonad
91. Antiemetic drugs treat which of the following conditions?
- A. bleeding
  - B. renal shutdown
  - C. fever
  - D. pain
  - E. vomiting
92. The Partial Thromboplastin Time (PTT) measures the coagulation cascade. \_\_\_\_\_ portion(s) of
- A. extrinsic
  - B. intrinsic
  - C. common
  - D. intrinsic and common
  - E. extrinsic and common
93. Atropine is used to:
- A. increase urine output
  - B. relieve preoperative anxiety
  - C. treat tachycardia
  - D. relax muscles
  - E. treat bradycardia

94. Furosemide acts on the
- A. distal convoluted tubule.
  - B. ascending limb of Henle.
  - C. glomerulus.
  - D. proximal tubule.
95. A cholinergic drug usually elicits:
- A. a wide-spread response
  - B. an area-specific response
  - C. vasoconstriction
  - D. increased preload
96. Which of the following could not be used as a pre-op medication?
- A. Benadryl
  - B. Fentanyl
  - C. Inapsine
  - D. Prostigmin
97. Which of these drugs acts on the receptors at the motor-end plates and is commonly used for intubation?
- A. anectine
  - B. verapamil
  - C. solumedrol
  - D. lasix
98. Acetylcholine is metabolized by which enzyme?
- A. monamine oxidase
  - B. catechol-o-methyl transferase
  - C. acetylcholinesterase
  - D. neo-synepherine
99. Which of the following clotting factors are deficient in stored blood but may be found in FFP?
- A. Factors II and VII
  - B. Factors V and VIII
  - C. Factors VIII and IX
  - D. Factors X and XII
100. What is the normal renal fraction of cardiac output?
- A. 5%
  - B. 12%
  - C. 20%
  - D. 32%

101. In reference to the oxygen supply/demand relationship of myocardium, oxygen demand may best be characterized by:
- A. TTI
  - B. DPTI
  - C. LVEDV
  - D. Systolic BP
102. The therapy for hyperfibrinolysis is the administration of \_\_\_\_\_, which inhibits fibrinolysis.
- A. heparin
  - B. protamine
  - C. coumarine
  - D. amicar
103. The average normal hemodynamic values of a newborn are: pulse \_\_\_\_\_, BP \_\_\_\_\_, respiratory rate \_\_\_\_\_.
- A. 100, 90/60, 50
  - B. 110, 85/60, 30
  - C. 110, 70/40, 30
  - D. 120, 70/40, 50
104. Which of the following will not cause an increase in PVR?
- A. arborization of pulmonary vasculature
  - B. smooth muscle hypertrophy of pulmonary arterial lumen
  - C. increased  $PCO_2$
  - D. decreased  $PO_2$
105. The relationship between stroke volume and end-diastolic volume is expressed by
- A. the Borelli Principle.
  - B. Marey's Law.
  - C. Starling's Law.
  - D. Boyle's Law.
106. Another term for the antidiuretic hormone (ADH) is
- A. furosemide.
  - B. angiotensin II.
  - C. vasopressin.
  - D. renin.
107. Reduced renal blood flow during cardiopulmonary bypass can be most directly attributed to
- A. reduced angiotensin II formation.
  - B. increased lasix levels.
  - C. renal vasodilation.
  - D. renal vasoconstriction.

108. Coagulation is specifically defined as the interaction of
- A. RBC's with plasma proteins.
  - B. Platelets with coagulation proteins.
  - C. RBC's with coagulation proteins.
  - D. Platelets with plasma proteins.
109. Which of the following is true of type O blood?
- A. Plasma has O antigen.
  - B. RBC's have A and B antigen.
  - C. Plasma has no A or B antibodies.
  - D. RBC's have no A or B antibodies.
110. The correct definition of cor pulmonale is:
- A. dual chamber LA
  - B. LV hypertrophy
  - C. pulmonary hypertension
  - D. atretic pulmonary valve
111. The average Cardiac Output per unit weight for a neonate is
- A. 75 cc/kg.
  - B. 175 cc/kg.
  - C. 275 cc/kg.
  - D. 350 cc/kg.
112. Dissection of the aorta just distal to the innominate artery down to the bifurcation would be characterized by
- A. increased left arm pressures.
  - B. increased perfusion of the left common carotid.
  - C. increased right arm perfusion.
  - D. increased right leg perfusion.
113. Normal serum potassium is approximately:
- A. 2.0 mEq/L
  - B. 0.4 mEq/100 cc
  - C. 0.6 mEq/100 cc
  - D. 8.0 mEq/L
114. Which vascular network is provided together with its appropriate percentage of cardiac output distribution?
- A. Bronchial - 10%
  - B. Cerebral - 15%
  - C. Renal - 30%
  - D. Integumentarial (Skin) - 5%
  - E. Hepatic/Portal - 20%

115. The T wave of the ECG normally represents
- A. A-V node deplarization.
  - B. repolarization of the ventricles.
  - C. repolarization of the left ventricle only.
  - D. depolarization of the ventricles.
116. Which of the following is a clinical diagnosis of cardiac dyskinesia?
- A. a decrease in the motion of the affected wall segment
  - B. total lack of contraction
  - C. paradoxical outward movement of the wall segment
  - D. a compensatory increase in the motion of the affected wall segment
117. Under normal physiological conditions, which organ has the lowest oxygen consumption per unit weight?
- A. brain
  - B. kidney
  - C. lungs
  - D. liver
118. Most potassium is found in which body compartment?
- A. intracellular
  - B. interstitial
  - C. extracellular
  - D. intravascular
119. The normal stroke volume for an average adult is
- A. 45-55 mL.
  - B. 70-80 mL/min.
  - C. 80-110 mL.
  - D. 0.07-0.08 L.
120. The least relevant preoperative evaluation for a pediatric patient with a CHD is:
- A. chest x-ray
  - B. heart sounds
  - C. ECG
  - D. general appearance, color, and activity
121. Activated Factor X is the first step in which of the following coagulation stages?
- A. intrinsic pathway
  - B. common pathway
  - C. waterfall sequence
  - D. extrinsic pathway

122. Which of the following decrease blood viscosity?
- A. decreased blood temperature
  - B. decreased hematocrit, increased blood temperature
  - C. decreased blood temperature, increased hematocrit
  - D. increased hematocrit
123. Select the correct statement.
- A. The medullary tissue of the kidney is hypotonic relative to arterial blood.
  - B. The hormone ADH is secreted from the anterior pituitary gland.
  - C. When the ADH level in the blood is high, the kidney produces more urine because the distal tubule and collecting duct become less permeable to water and less water is reabsorbed.
  - D. Erythropoietin is a hormone produced by the kidney and is responsible for increasing red cell production.
124. Upon examination of a child using a doppler echocardiogram, a 3 m/s tricuspid insufficiency is measured. What is the child's RV systolic pressure (CVP = 10 mmHg)?
- A. 36 mmHg
  - B. 46 mmHg
  - C. 56 mmHg
  - D. 66 mmHg
125. Which of the following events does not occur during the vascular spasm phase of hemostasis?
- A. Edema
  - B. Shunting
  - C. Sequestering
  - D. Chemotaxis
126. Choose the most correct statement.
- A. Type O blood has anti-A and anti-B agglutinogens in their RBC's.
  - B. Type B blood is the most commonly found blood type, followed by type O, type A, and finally type AB.
  - C. The O negative blood type is known as the universal donor.
  - D. If an Rh negative patient receives Rh positive blood for the first time, a traumatic transfusion reaction will occur.
127. Choose the most correct answer.
- A. A left-to-right shunt will cause a child's arterial saturation to be desaturated when compared to normal values.
  - B. Peripheral cyanosis is a sympathetic response characterized by blue extremities and is associated with a normal PaO<sub>2</sub>.
  - C. In reference to oxygenators, a wettable surface is more traumatic than a non-wettable one.
  - D. A neonate presenting with a blue Tetralogy of Fallot is a non-surgical candidate.

128. Choose the most correct statement.
- A. Viscosity is defined as the shear rate divided by the shear stress.
  - B. The perfusion provided to an organ is directly proportional to the driving pressure, the vascular radius, and the viscosity of blood.
  - C. Organ vascular resistance is directly proportional to vessel length and blood viscosity.
  - D. The pressure gradient across either a vascular bed or a length of arterial CPB tubing is inversely proportional to blood flow.
129. Which of the following is responsible for the osmotic force in the plasma?
- A. albumin
  - B. fibrinogen
  - C. glutinogen
  - D. serotonin
130. Which of the following control vascular resistance in the human body?
- A. arterioles
  - B. arteries
  - C. venules
  - D. veins
131. End-Diastolic ventricular volume may be
- A. decreased by decreasing the diameter of arterioles.
  - B. augmented by reducing ventricular compliance.
  - C. decreased by increasing respiratory movements.
  - D. reduced by venous constriction.
  - E. elevated with the action of the "skeletal muscle pump."
132. A hyperosmotic fluid will cause water to migrate from within the erythrocytes to the exterior of the erythrocytes, resulting in
- A. crenation.
  - B. hemolysis.
  - C. swelling.
  - D. clotting.
133. Which of the following is the most commonly faced problem of premature babies?
- A. reversible PFO
  - B. immature RV
  - C. liver dysfunction
  - D. pulmonary dysfunction
134. Choose the incorrect characteristic of the neonatal heart as it is compared to the adult heart.
- A. greater deficiency of contractile tissue
  - B. higher vagal tone
  - C. greater dependency on Starling's curve for cardiac reserve
  - D. stroke volume is more dependent on afterload

135. The complement system is critical to the mechanisms of:
- A. blood-gas exchange
  - B. glucose metabolism
  - C. inflammation and phagocytosis
  - D. renal excretion of macro-proteins
136. Choose the most correct statement.
- A. Starling's "Law of the Heart" states that over a normal operating range, increasing end-diastolic ventricular volume will lead to an increased stroke volume.
  - B. Oxygen uptake by organs is dependent on the metabolic rate of the specific tissue.
  - C. For all systemic vascular beds, organs with a high oxygen extraction also receive a high proportion of the cardiac output.
  - D. Blood flow to the kidneys is about 20% of cardiac output, whereas the heart muscle receives 15% of the cardiac output.
137. Disseminated intravascular coagulation (DIC), pulmonary embolism (PE), cirrhosis of the liver, and burns may all increase the amount of
- A. tissue plasminogen activator.
  - B. circulating platelets.
  - C. fibrin degradation products.
  - D. hemostatic action.
138. Which of the following is (are) true regarding the autonomic nervous system?
- A. As a general rule, stimulation of the adrenergic neurons results in excitation of an organ (e.g. accelerates heart rate).
  - B. As a general rule, stimulation of the cholinergic neurons results in excitation of an organ (e.g. accelerates heart rate).
  - C. Cells which liberate adrenaline-like substances are called adrenergic and are released by cells of the parasympathetic system.
  - D. Cells which liberate acetylcholine-like substances are called cholinergic and are released by cells of the sympathetic system.
139. A base excess (BE) of -8.0 accompanied by a physiologically normal  $PCO_2$  would most likely indicate which of the following?
- A. respiratory acidosis
  - B. respiratory alkalosis
  - C. metabolic acidosis
  - D. metabolic alkalosis
140. Glomerular filtration
- A. is an active transport process.
  - B. will decrease as the protein osmotic pressure of the plasma rises.
  - C. is equal in volume to the volume of urine formation.
  - D. tends to increase circulating potassium levels.

141. The greatest increase in insulin levels occurs during which phase of open-heart surgery?
- A. prebypass
  - B. on bypass during hypothermia
  - C. on bypass during rewarming
  - D. postbypass
142. Which of the following is the most correct statement?
- A. For the systemic circulation as a whole, the arterial pressure is determined by the product of cardiac output and the resistance to flow offered by the systemic vascular beds.
  - B. The blood flow through individual vascular networks is directly proportional to the vascular resistance in these networks.
  - C. Vascular resistance is largely determined by the large and small artery segments of the vasculature, not by the arteriolar sections of the network.
  - D. Cardiac output is determined by dividing stroke volume by heart rate.
143. In what body compartment is most water found?
- A. intravascular
  - B. intracellular
  - C. interstitial
  - D. extracellular
144. Which of the following represents the correct order of the four hemostatic processes?
- A. platelet plug, vascular spasm, coagulation cascade, fibrin clot
  - B. contact, adhesion, spreading, aggregation
  - C. coagulation cascade, fibrin formation, fibrin clot, hemostasis
  - D. vascular spasm, platelet plug, coagulation cascade, fibrin clot
145. Choose the most correct statement.
- A. Cerebral oxygen consumption is increased with CPB.
  - B. The pH-stat method of blood gas control on CPB reduces the non-temperature corrected  $\text{CO}_2$ , which produces a lower cerebral blood flow compared to values observed when using the alpha-stat method.
  - C. The use of an arterial line filter in the CPB circuit may improve neurological outcomes following surgery.
  - D. Neuropsychological deficits are rare following myocardial revascularization.
146. In a state of disseminated intravascular coagulation (DIC), which of the following clotting factors will be lost faster than the liver is able to replenish them?
- A. Factors I, III, and VIII
  - B. Factors I, V, and VIII
  - C. Factors I, VII, and X
  - D. Factors I, V, and X

147. Which of the following is true concerning the P wave of the ECG?
- A. During the P wave, ventricular depolarization occurs.
  - B. During the P wave, the atrioventricular valves are open.
  - C. During the P wave, the ventricles are undergoing isovolumetric contraction.
  - D. During the P wave, atrial repolarization occurs.
148. Thrombin added to a plasma sample will form fibrin within 10 seconds in all but which of the following circumstances?
- A. functionally active fibrinogen is present.
  - B. heparin is absent.
  - C. fibrin degradation products are absent.
  - D. AT-III is present.
149. Select the incorrect statement.
- A. Secretion of hydrogen ions into the renal tubules helps regulate the acidity of the extracellular fluids of the body.
  - B. A rise in plasma volume following a fall in ADH concentration in the circulating blood is common.
  - C. During alkalemia, bicarbonate reabsorption by the kidney is decreased.
  - D. An increase in blood volume will decrease the secretion of ADH.
  - E. In the absence of ADH, most of the fluid entering the collecting ducts appears in the urine.
150. Fill in the two missing steps of platelet plug formation in correct order:
1. Contact
  2. Spreading
  3. Aggregation
  4. ADP release
  5. Shunting
- A. (2) Edema; (4) Shunting
  - B. (2) Adhesion; (4) ADP release
  - C. (2) Shunting; (4) Edema
  - D. (2) ADP release; (4) Adhesion
151. What is the normal A-V O<sub>2</sub> content difference?
- A. 25 vol%
  - B. 5 vol%
  - C. 10 vol%
  - D. 15 vol%
152. Which of the following will not stimulate platelet aggregation?
- A. Prostacyclin
  - B. ADP
  - C. Serotonin
  - D. Thromboxane A<sub>2</sub>
  - E. Arachidonic acid

153. Which statement is true?
- A. Neonates with a CHD who develop pulmonary hypertension are in a lethal state because, while their cardiac problems may be repaired, in the end the child will exhibit a high PVR which the RV can not pump against and will ultimately go into failure.
  - B. Alkalosis, hypotension, and a rise in blood lactate levels all result from hypoperfusion and shock.
  - C. Decreased capillary permeability (capillary leakage) is most commonly associated with complement activation.
  - D. Transposition of the great vessels is considered an acyanotic heart defect.
154. Which law states that the wall tension of a vessel resistant to pressure is equal to the vessel radius multiplied by the transmural pressure?
- A. Starling's Law
  - B. La Place's Law
  - C. Boyle's Law
  - D. Gay-Lussac's Law
155. What is the major determinant of cerebral blood flow?
- A.  $p\text{CO}_2$
  - B.  $p\text{O}_2$
  - C. cardiac output
  - D. aortic pressure
156. The following arterial blood gas is characteristic of partially compensated metabolic acidosis:
- A.  $\text{pH} = 7.39$ ,  $p\text{CO}_2 = 28$  mmHg,  $p\text{O}_2 = 85$  mmHg,  $[\text{HCO}_3^-] = 19$  meq/L
  - B.  $\text{pH} = 7.28$ ,  $p\text{CO}_2 = 38$  mmHg,  $p\text{O}_2 = 185$  mmHg,  $[\text{HCO}_3^-] = 19.5$  meq/L
  - C.  $\text{pH} = 7.42$ ,  $p\text{CO}_2 = 37$  mmHg,  $p\text{O}_2 = 250$  mmHg,  $[\text{HCO}_3^-] = 23$  meq/L
  - D.  $\text{pH} = 7.37$ ,  $p\text{CO}_2 = 30$  mmHg,  $p\text{O}_2 = 115$  mmHg,  $[\text{HCO}_3^-] = 28$  meq/L
157. The universal blood recipient is which of the following?
- A. AB Positive
  - B. AB Negative
  - C. O Positive
  - D. O Negative

158. Choose the least correct statement.
- A. Alveolar air ordinarily has a water vapor pressure of 47 mmHg.
  - B. Atmospheric air contains a higher partial pressure of oxygen than alveolar air.
  - C. In the alveolus, the partial pressure of carbon dioxide is about 40 mmHg, whereas the atmospheric air has a  $p\text{CO}_2$  of less than 3 mmHg.
  - D. The solubility of a gas in solution is increased as the solution temperature increases.
159. Choose the correct statement.
- A. Heparin levels must be monitored carefully during CPB of a pregnant patient because of the risk of intracranial bleeding in the fetus as the heparin crosses the placenta.
  - B. One of the distinct advantages V-V ECMO has over V-A ECMO is its ability to supply direct cardiac support.
  - C. Hydroxyethyl starch has been shown to control interstitial fluid accumulation better than albumin, and it is less expensive.
  - D. Bubble point pressure is defined as the pressure change across a filter at which point gas bubbles will pass through the filter.
160. Choose the incorrect statement.
- A. Pulsatile flow has been proven to increase hemolysis, platelet destruction, and coagulopathies.
  - B. The ph-stat method requires the  $p\text{CO}_2$  to be increased during hypothermia in order to maintain a normal pH.
  - C. A decreased pH (acidosis) shifts the oxyhemoglobin dissociation curve to the right, resulting in lower oxygen affinity to hemoglobin at the same partial pressure.
  - D. Centrifugal pumps will not overpressurize CPB lines because they are both preload and afterload dependent.
161. Left heart failure would be an indication for all of the following modes of therapy except:
- A. LVAD
  - B. IABP
  - C. RVAD
  - D. Reinstitution of CPB
162. Choose the most incorrect statement.
- A. Heparin must be used in veno-venous bypass systems while supporting the circulation in all liver transplantation surgeries.
  - B. Cyclosporin therapy in organ transplantation patients decreases the function of T-helper lymphocytes, which inhibits the actions of the immune system.
  - C. During liver transplantation, the use of an extracorporeal shunt enables a stable venous return and assures decompression of the lower caval and portal venous systems.
  - D. Liver transplant patients may benefit from the use of an intraoperative rapid infusion system.

163. At 30°C, a patient is considered to be in which level of hypothermia?
- A. mild
  - B. moderate
  - C. deep
  - D. profound
164. Choose the more correct statement.
- A. The hypothermia of CPB increases blood viscosity and may cause vascular constriction.
  - B. Carotid sinus and aortic arch baroreceptors are exposed to an increased stretch upon initiation of CPB.
  - C. Plasma catecholamines, vasopressin, and histamine all decrease in concentration during CPB.
  - D. The mean arterial pressure often increases upon initiation of CPB.
165. If a child on ECMO begins to exhibit pulmonary improvement, assuming reasonable cardiac function and no change in ventilator settings, the PaO<sub>2</sub> of the child's airway would be expected to
- A. fall.
  - B. stay the same.
  - C. increase.
  - D. change erratically.
166. The optimal average blood flow rate for neonates while on CPB ranges between
- A. 40 - 80 cc/kg/min.
  - B. 80 - 120 cc/kg/min.
  - C. 120 - 160 cc/kg/min.
  - D. 160 - 200 cc/kg/min.
167. The Activated Clotting Time (ACT) test
- A. uses activated charcoal.
  - B. demonstrates a linear dose-response between dose and ACT extension.
  - C. becomes more accurate with higher heparin dosages.
  - D. is extremely reliable under hypothermic conditions.
168. Pulsatile blood flow is known to do all of the following except
- A. decrease the peripheral vascular pressure.
  - B. alter the catecholamine levels.
  - C. increase the urinary output.
  - D. better mimic the flow characteristics of the heart.

169. Choose the clinical situation which would most likely result in a respiratory acidosis during CPB.
- A. an excessive gas-to-blood flow ratio
  - B. an inadequate CO<sub>2</sub> in the ventilation gas mixture
  - C. an inappropriately high oxygenator ventilation circuit, leading to hyperventilation
  - D. a wetting of the membrane oxygenator, which obstructs the gas flow and leads to hypoventilation
170. Which of the following is not true of prostacyclin (PGI<sub>2</sub>) use in conjunction with CPB?
- A. The purpose of its use is to inhibit platelet aggregation.
  - B. Use of PGI<sub>2</sub> may produce significant hypertension.
  - C. PGI<sub>2</sub>'s short half-life allows rapid return of platelet function upon cessation of treatment.
  - D. Glomerular filtration is increased through its vasodilating effects.
171. Cardiac index (CI) is expressed in units of
- A. L/min<sup>2</sup>.
  - B. Liters (L).
  - C. L/min/m<sup>2</sup>.
  - D. L/min.
172. In order to reduce the complement activation associated with donor products, it is important to utilize all of the following except
- A. fresh blood products.
  - B. CMV negative blood.
  - C. leukocyte depleted blood.
  - D. CPD depleted blood.
173. Choose the most correct statement.
- A. Myocardial energy stores may be theoretically maintained or enhanced with the infusion of cardioplegia solutions containing substrates.
  - B. Bicaval cannulation assists in maintaining adequate myocardial protection because of the technique's relative effectiveness of keeping the heart warm.
  - C. Mg<sup>++</sup> has never been used as a cardioplegic constituent chemical.
  - D. Substrates given during the administration of cardioplegia are just as beneficial when given cold as when they are given warm.

174. Choose the most correct statement.
- A. Hypoventilation of a blood oxygenator during CPB may lead to a decrease in the ratio of bicarbonate ions to carbonic acid concentrations, and respiratory alkalosis will result.
  - B. With a decreased ventilation of the lungs, as in a chronic lung disease like emphysema, a respiratory alkalosis may result.
  - C. A high arterial blood carbon dioxide level in the blood exiting an oxygenator may be the result of a high carbon dioxide level in the venous blood at the oxygenator inlet.
  - D. The oxygen content of the hemoglobin and the bloodstream is a primary determinant of a respiratory acidosis or a respiratory alkalosis.
175. Choose the most correct statement.
- A. For infants presenting for heart surgery, the degree of hemodilution on CPB should be decided solely on the basis of patient size, with blood temperature during CPB rendered relatively unimportant.
  - B. One-fourth inch I.D. pump tubing carries approximately 38 cc per foot of tubing length.
  - C. For a child of 8 kg body weight, an 18 Fr. aortic perfusion cannula would be appropriate.
  - D. It is possible to use lower internal diameter pump tubings for CPB in children because of their absolute blood flow requirements.
176. A pulmonary artery diastolic pressure (PAD) of 3-5 mmHg is also the best indicator of the
- A. LA filling pressure.
  - B. LV end diastolic pressure.
  - C. RA filling pressure.
  - D. RV afterload.
177. Gravitational venous return
- A. generally requires a height differential of approximately 25-30 cm.
  - B. offers greater control over fluid balance than does pump venous return.
  - C. is mandatory in left heart bypass.
  - D. is desirable only while on partial bypass.
178. Circulating blood volume is calculated using which of the following values?
- A.  $0.8 \text{ L/kg} * \text{kg}$
  - B.  $0.08 \text{ L/kg} * \text{kg}$
  - C.  $0.08 \text{ L/kg} * \text{kg} * \text{HCT}$
  - D.  $0.08 \text{ L/kg} * \text{kg} * 1.34$

179. Which level of heparinization is commonly used during ECMO?
- A. no heparinization
  - B. 1.5 to 2.0 baseline
  - C. 2.5 to 3.0 baseline
  - D. full heparinization
180. The average cardiac index for a neonate with a BSA of  $0.75 \text{ m}^2$  is
- A.  $100 \text{ cc/min/m}^2$ .
  - B.  $233 \text{ cc/min/m}^2$ .
  - C.  $366 \text{ cc/min/m}^2$ .
  - D.  $500 \text{ cc/min/m}^2$ .
181. A decrease in temperature and 2,3 DPG will cause the oxyhemoglobindissociation curve to
- A. shift leftward.
  - B. shift rightward.
  - C. shift upward.
  - D. remain unchanged.
182. Which of the following prime solutions is known to be isotonic?
- A. lactated ringers
  - B. normal saline
  - C. plasmalyte combined with 6% hetastarch
  - D. D5W sterile water
183. Which of the following is not a component of an ECMO circuit?
- A. oxygenator bypass line
  - B. arterial line filter
  - C. A-V bypass loop
  - D. heat exchanger
184. The average overall survival rate for pediatric ECMO therapy is:
- A. 93%
  - B. 83%
  - C. 73%
  - D. 63%
185. Choose the incorrect statement.
- A. A higher gas-to-blood flow ratio during CPB may lead to respiratoryacidosis.
  - B. Higher  $\text{CO}_2$  levels in the ventilating gas delivered to an oxygenator may lead to a lower blood pH.
  - C. Lower blood flows on CPB during rewarming may lead to metabolicacidosis.
  - D. The hematocrit reduction of CPB, if excessive, may lead to a loss of bicarbonate.

186. High aortic line pressures may result from all of the following except
- A. cannula size.
  - B. aortic dissection.
  - C. venous pressure.
  - D. flow rates.
187. Which of the following is the most appropriate parameter for removal of the aortic cross clamp?
- A. MAP of 20 mmHg
  - B. CPB blood flow of 2.7 L/min
  - C. MAP of 98 mmHg
  - D. T<sub>CORE</sub> of 35.0°C
188. Which of the following tests provides an actual heparin level?
- A. ACT (Activated Clotting Time)
  - B. HDR (Heparin Dose Response)
  - C. HPT (Heparin-Protamine Titration)
  - D. Sonoclot
189. Cardiac output (CO) is expressed in units of
- A. L/min<sup>2</sup>.
  - B. Liters (L).
  - C. L/min/m<sup>2</sup>.
  - D. L/min.
190. IABP therapy has been suggested to increase coronary blood flow by
- A. providing the coronaries with an increased filling pressure during systole.
  - B. providing the coronaries with an increased filling pressure during diastole.
  - C. decreasing the workload on the left ventricle.
  - D. decreasing the workload on the right ventricle.
191. Improper placement of the IVC cannula (overinsertion) might obstruct which vessel?
- A. renal artery
  - B. hepatic artery
  - C. hepatic vein
  - D. femoral vein
192. Choose the correct statement.
- A. Heparin will lyse some existing clots.
  - B. Celite is an activator used for the ACT test.
  - C. It is more desirable to administer blood cardioplegia at 4°C rather than at 20°C primarily because of the increased viscosity associated with blood at lower temperatures.
  - D. Ischemic injury is synonymous with reperfusion injury.

193. During bi-caval venous cannulation, what monitoring parameter indicates cerebral blood flow?
- A. systemic pressure
  - B. central venous pressure
  - C. perfusion pressure
  - D. pulmonary artery pressure
194. Which of the following is not a widely accepted criticism of the intermittent aortic cross clamping technique?
- A. normal coronary blood flow is not assured during reperfusion
  - B. energy demand is excessive
  - C. ischemic periods are cumulative, increasing myocardial infarction potential
  - D. procedure is technically difficult
195. When titrated heparin and nitroglycerin drips are discontinued abruptly before CPB, the ACT will
- A. decrease rapidly.
  - B. increase slowly.
  - C. increase rapidly.
  - D. will remain the same.
196. Choose the most correct statement.
- A. Normally, hemoglobin is 27% saturated at a plasma  $pO_2$  of 50 mmHg; this is defined as the  $P_{50}$  of blood.
  - B. If the  $P_{50}$  of blood rises, this is an indication of right-shifting of the oxyhemoglobin saturation curve; this means that oxygen is more tightly bound to the hemoglobin molecule.
  - C. As the pH of the blood falls, the oxyhemoglobin curve would shift to the right and the  $P_{50}$  would fall.
  - D. As the tissue temperature falls with hypothermic CPB, a rightward shift of the oxyhemoglobin dissociation curve occurs and oxygen is released.
197. The activated clotting time (ACT) and the activated partial thromboplastin time (aPTT) both evaluate which coagulation mechanism?
- A. extrinsic
  - B. common
  - C. intrinsic
  - D. heparin effect
  - E. complement
198. The maximum rated blood flow of an oxygenator is known as the
- A. oxygen blood flow.
  - B. hemolysis index.
  - C. reference blood flow.
  - D. blood-gas transfer index.

199. When running a bubble oxygenator, a low venous oxygen saturation is an indication to
- A. increase the gas sweep.
  - B. decrease the  $FiO_2$ .
  - C. increase the speed of the arterial pump head.
  - D. increase the isoflurane percentage.
200. Bubble Point pressure may be increased by
- A. decreasing the surface tension of the fluid.
  - B. increasing the surface tension of the fluid.
  - C. decreasing the pore diameter of the filter.
  - D. increasing the pore diameter of the filter.
  - E. b and c.

1. A,A,B,B,A,D,C,A,C,A,C,C,A,C,C,D,B,B,C,A  
 21. C,A,A,D,C,A,D,A,C,A,D,C,C,A,C,D,C,B,D,A  
 41. C,B,A,C,C,A,B,D,D,C,B,D,E,C,B,C,E,A,A,C  
 61. D,C,A,A,D,C,A,C,C,C,B,B,B,A,A,B,D,B,B,C  
 81. D,A,B,D,A,B,C,D,D,C,E,D,E,B,B,D,A,C,B,C  
 101. A,D,D,A,C,C,D,B,D,C,B,C,B,B,B,C,B,A,D,C  
 121. B,B,D,B,C,C,B,C,A,A,E,A,D,C,C,A,C,A,C,B  
 141. C,A,B,D,C,B,B,D,B,B,B,A,A,B,A,A,A,D,D,A  
 161. C,A,B,A,A,B,B,B,D,B,C,D,A,C,D,A,A,B,B,B  
 181. A,C,B,B,A,C,D,C,D,B,C,B,C,D,A,C,C,C,C,

**Perfusion****Thesis Approval Form****Master of Science in Perfusion - MSP****Milwaukee School of Engineering**

This thesis, entitled “Completing the Development of Multiple Choice Quizzes and Practice Exams for the Master of Science in Perfusion Students at Milwaukee School of Engineering,” submitted by the student Stefan Jacobson, has been approved by the following committee:

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