

**The Development of Comprehensive Intra-Aortic Balloon Pump (IABP)**  
**Review Material for Perfusion Students**

by

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## Abstract

The Milwaukee School of Engineering (MSOE) Master of Science in Perfusion (MSP) program has a reputation for graduating quality perfusionists. Operating and maintaining an intra-aortic balloon pump (IABP) is an important ancillary role associated with perfusionists and the perfusion curriculum. However, feedback from recent graduates and their new employers indicates that graduates are not fully comfortable operating IABPs. This may be because this topic is covered in the middle of the program and not reinforced throughout. To provide additional instruction and review, a study guide containing a comprehensive collection of IABP techniques and additional preparation material was created. Content contained in this guide is designed to be accompanied by a video, *Intra-aortic Balloon Pumps: A Review for Healthcare Professionals*, also created as a part of this project. Additionally, evaluation criteria and an exam were generated to gauge students' level of understanding. Surveys distributed to perfusion students and faculty regarding the content of this material indicated that the material presented is both accurate and helpful. If implemented in a systemic manner in the MSOE perfusion curriculum, it is expected that future graduates will report a greater comfort level using IABPs.

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## **1.0: Introduction**

The intra-aortic balloon pump (IABP) is a commonly inserted device to help patients suffering from myocardial infarction, cardiogenic shock, or other cardiac diseases [1]. It is effective because it increases blood flow down the coronary arteries and reduces the workload on the heart [2]. This increases the supply of oxygen-rich blood while reducing the demand [3]. At some surgical centers, the job description and duties of perfusionists include the operation of the IABP, and it is common for perfusionists to operate this device when a patient fails to wean from cardiopulmonary bypass [4, 5]. Therefore, it is an important part of perfusionist training and employer expectations.

Perfusion students in the Milwaukee School of Engineering (MSOE) Master of Science in Perfusion (MSP) program currently experience a didactic curriculum and limited clinical exposure relating to IABP use [6]. However, the overall experiences may not be adequate for graduates to leave the program confident in their ability to use this technology. This is evident from both student and employer feedback. One employer of a new graduate of the MSOE perfusion program stated their new perfusionist “had little hands-on experience” with intra-aortic balloon pumps. Even when considered as an ancillary role of perfusionists, the IABP technical skills of MSOE perfusion graduates or lack of such skills reflects on the standing of the MSOE perfusion program as a whole.

The goal of this project was to provide substantial supplemental material that students can use to review and refresh their understanding of IABP techniques before starting their employment. These materials contain the content currently in the MSOE curriculum, as

well as applicable materials not currently covered. To provide comprehensive review material and to appeal to all learning styles, different mediums of material were created. Through the use of a reference guide, an interactive video, and a self-paced evaluation, all students will gain additional exposure to intra-aortic balloon pumps prior to employment.



## **2.0: Background**

### **2.1: Use of Intra-Aortic Balloon Pump**

The use of intra-aortic balloon pumps (IABPs) in treating myocardial infarction and mechanical heart complications is common [7]. IABPs are effective for these patients because they produce increased coronary perfusion while reducing the workload on the heart [1, 2]. By increasing blood supply to the myocardium and decreasing its demand for oxygenated blood, the IABP ensures that the myocardium is less likely to become hypoxic, thereby improving recovery [8, 9]. IABP support is also common in patients who fail to wean from cardiopulmonary bypass for similar reasons [10]. In this situation, perfusionists often have significant interaction with the device [4]. In fact, the main indication for use of IABP in cardiac surgical patients is the peri-operative treatment of low cardiac output. One study found about 5% of all cardiac surgical patients require IABP support [10]. Although an IABP is only recommended for use in conjunction with other treatments, the variety of situations in which an IABP can be effective makes it widely used.

Since IABP technology was first introduced in 1962, its use has greatly increased [11]. From 1986-1997, the IABP was used on 20% of patients who experienced cardiogenic shock [12]. This increased to 42% by 1997 and has continued to increase since then [12, 13]. A recent large trial, called the “Should We Emergently Revascularize Occluded Coronaries for Cardiogenic Shock (SHOCK)” trial, evaluated the most beneficial approach to treating patients with a myocardial infarction [14]. Although the trial mainly explored the effectiveness of emergency revascularization, other treatment strategies

were also analyzed. In the SHOCK trial, IABP support was used in 86% of the 302 patients with heart failure that was secondary to ST-Elevation Myocardial Infarction (STEMI) or cardiovascular shock [15]. The high frequency of IABP use in the SHOCK trial suggests balloon pumps are a key component of the overall treatment plan for patients with myocardial infarcts and cardiogenic shock. In fact, intra-aortic balloon pumps are currently the most commonly used cardiac assist device in critically ill patients with cardiac diseases [16]. In the United States alone during the year 1990, there were more than 70,000 patients on IABP support [11]. This number has grown since then and is expected to continue to grow [17].

Based on results from studies such as the SHOCK trial, intra-aortic balloon pumps are now indicated for use in patients with STEMI [18]. The 2013 American College of Cardiology/American Heart Association (ACCF/AHA) guidelines suggest IABP use is beneficial in patients with STEMI who do not quickly stabilize with pharmacological therapy [18]. This is deemed a class IIa recommendation with a B level of evidence [18]. This means the weight of evidence is in favor of usefulness/efficacy, and the data were derived from a single randomized trial or multiple nonrandomized studies [19]. As evidence for balloon pump therapy expands and its use increases, the demand for knowledgeable operators also grows.

## **2.2: Operators of Intra-Aortic Balloon Pumps**

Throughout the history of intra-aortic balloon pump use, various healthcare professionals have been responsible for operating the technology [20]. Doctors, physician assistants, perfusionists, and nurses all have a role in the care of patients with an IABP [5, 21, 22]. As IABP devices progress in their design, they become easier to use. More user-friendly interfaces, automated timing, and alarms with troubleshooting prompts make operation more intuitive for all users [7, 17, 22] .

Each institution has specific protocols guiding healthcare professionals on how to perform certain tasks relating to IABP operations [22]. These protocols often depend on the size of the institution and the experience level of the cardiac healthcare professionals [22, 23]. For many institutions, medical doctors or physician assistants are only allowed to perform the insertion and removal of balloon catheters [24]. In cardiac intensive care units, nurses are largely responsible for the maintenance of patients [21]. Managing IABPs in the operating room is usually the responsibility of the perfusionist or anesthesia monitoring technician [4, 5]. There are special circumstances in the operating room that require more attentive IABP operators. These include monitoring anticoagulation status, pausing the balloon during cannulation, and changing the trigger source when required [3]. These tasks require a certain level of understanding about cardiac operating room procedures, which are well known to perfusionists [5].

The American Society of Extracorporeal Technology (AmSECT) is a professional society that is devoted to providing professional and educational needs for the extracorporeal

circulation technology community, specifically perfusionists [25]. AmSECT has developed the *Standards and Guidelines for Perfusion Practice*, which describes the role of perfusionists and their scope of practice [26]. In this document, Section 18 (“Maintenance”) describes the equipment perfusionists are responsible for. Section 18 states, “The Perfusionist shall assure that properly maintained and functioning equipment is used in the conduct of cardiopulmonary bypass (CPB), including (but not limited to),” which is followed by a list of equipment [26]. Under ancillary equipment, IABP is listed. AmSECT is regarded as the primary source for perfusion-related information, and IABP operation is listed as standard equipment that perfusionists must maintain and become proficient in [25]. To adequately perform this ancillary role, perfusionists must have the proper training on IABP function and maintenance.

### **2.3: Feedback from Employer and Graduate Surveys**

To continually improve, the Milwaukee School of Engineering (MSOE) Master of Science in Perfusion (MSP) program requests feedback from recent graduates and their employers. These surveys are sent out between six months and one year after the start of the graduate’s employment, and they are intended to collect data on the strengths and weaknesses of the program to keep the program current with an evolving industry [4]. The survey does not directly ask about the IABP curriculum, but open-ended questions leave space for comments. Both employers and recent graduates provide valuable perspectives and their insights deserve attention.

When employers were asked questions such as, “What qualities or skills did you expect of the graduate upon employment that he/she did not possess?” and, “What suggestions for improvement in training of future graduates would you like to make?,” many commented that further IABP experience would be beneficial. A summary of these employer survey responses and their comments is shown in Table 1.

**Table 1. The Results of Employer and Recent Graduate Surveys are Summarized for Graduating Classes 2011 through 2016.**

<b>Year of Surveys</b>	<b>Survey Source</b>	<b>Number of Responses</b>	<b>Surveys Indicating More IABP Exposure is Desired</b>	<b>Examples of Comments Relating to IABP Training</b>
2011-2016	Employers	23	26%	“not adept at IABP operation,” “knew very little about autotransfusion, IABP, and other ancillary duties,” and additional IABP training in “transporting, initial setup, slave IABP in OR” would be beneficial
2011-2016	Recent Graduates	30	23%	“More experience with VADs and IABPs, even if it is just didactic,” “I understand that it's a little harder at MSOE to get extensive IABP, cell saver, and ECMO experience, but more focus on troubleshooting these devices would be extremely beneficial,” and “IABP - I felt like I had some knowledge but not enough to be able to insert/transport a patient.”

Many recent MSOE graduates also commented on their lack of comfort with IABPs. When asked, “Based on your work experience, make two or three suggestions to further strengthen the program” and “What qualities/skills were expected of you upon employment that were not included in the program?,” many responded with recommendations to further the IABP curriculum. Some of these comments are displayed in Table 1. The number and types of comments made by graduates of the MSOE MSP program indicate a weakness in the IABP curriculum, especially with specific topics.

Since the comments regarding IABP techniques in these surveys, from both employers and recent graduates, were unprompted, they have significant value. The number of comments directed at the IABP curriculum suggests an opportunity for additional program improvement and content review. Specifics in many of these comments include IABP operations, such as transporting patients with IABP support, slaving of the patient’s monitor, and the initial setup.

#### **2.4: Core Competencies and Clinical Competency Assessment**

A set of Core Competencies for Intra-Aortic Balloon Pumps exist to outline the level of IABP technique required of MSOE students and expected by employers. Setting the standard for an expected level of understanding, these competencies play a major role in student expectations. These competencies were developed by Joseph Check in a 2015 MSOE MSP thesis, titled *Recommendations for Improvements in Ancillary Perfusion*

*Services Training in the Milwaukee School of Engineering Master of Science in Perfusion Program* [27]. The competencies are shown in Appendix D.

A clinical competency exam is administered to students in the existing curriculum and is displayed in Appendix F (“Current MSOE MSP IABP Clinical Competency Exam”).

Check created an updated version of the competency exam [27]. The updated version, the “IABP Objective-based Clinical Competency Assessment,” is found in Appendix E. Both the current and updated assessment tools provide critical material that students are expected to know. For review material to be effective, it must incorporate the Core Competencies and detail the information required to successfully complete either the current or Check’s revised competency assessment. Ultimately, these competencies and assessments are testing a student’s own confidence in IABP operation and the ability to meet the demands of their future employer.

## **2.5: Current MSOE IABP Training**

The Milwaukee School of Engineering (MSOE) has educated students in perfusion since 1983, and in 1993, the program began offering a master’s degree, the Master of Science in Perfusion (MSP) [6]. MSOE’s MSP program mainly focuses on cardiopulmonary bypass of adult patients with various cardiovascular diseases. Students spend a significant amount of time learning about the heart-lung machine and its role in cardiac surgery. In addition, ancillary perfusion responsibilities are academically covered. Didactic and clinical learning occurs simultaneously throughout the two-year program [6].

The current clinical curriculum has students mainly responsible for operating the heart-lung machine, while perfusion clinical instructors perform all ancillary tasks. In case-based evaluations, student evaluations are not focused on these ancillary roles, only tasks associated with the heart-lung machine. Throughout the MSP program, clinical IABP exposure is limited to infrequent cardiac surgeries and a brief academic seminar. The main education on IABPs occurs in the Seminar on Clinical Medicine course. An experienced instructor in the spring quarter of the program's first year currently teaches this course. Of the ten weeks of content, IABP subject matter is covered in about four weeks. Other course content includes assist devices, such as ventricular assist devices, total artificial hearts, hemodialysis, and heart transplants.

In terms of the IABP curriculum, the course covers many aspects of balloon pumps. A list of course content includes effects on the cardiac cycle, anatomy of an augmented pressure waveform, determinants of myocardial oxygen supply and demand, catheter insertion sites, secondary physiological effects, indications, contraindications, timing, timing errors, frequency, and complications. Because of time constraints, some of the material is arguably superficially covered and other material is completely excluded.

Students in this course are evaluated with a didactic quiz on the course content. In addition, a pass-fail clinical evaluation is conducted. A copy of the evaluation form is located in Appendix F ("Current MSOE MSP IABP Clinical Competency Exam"). In this evaluation, students are briefly tested on their ability to perform select IABP techniques. These tasks include powering up the IABP console, initiating the IABP, adjusting augmentation, optimizing inflation and deflation timing, adjusting balloon frequency, and



responding accordingly to an alarm prompt. The evaluation is performed with a simulator attachment for the IABP, which displays imitations of ECG and blood pressure signals. Once the clinical evaluation is passed by students, they are not re-tested on IABP material, and exposure to balloon pumps is limited to sporadic encounters in the operating room.

Receiving feedback on tasks is essential to the learning process [28]. Each day students have a case, they are assessed on the many tasks they perform. This procedure provides them with timely feedback on their skills relating to specific tasks and overall progress. Some of these evaluated tasks include cardiopulmonary bypass (CPB) planning, circuit preparation, anticoagulation concepts, cannula selection and placement, initiating CPB, hemodynamic and volume management, cardioplegia administration, weaning from CPB, overall procedural awareness, communication, and many others. However, ancillary roles are not focused on. There is a comment section where instructors can personally describe ancillary tasks performed and provide feedback to students, although few instructors do so. This is likely because of the irregularity of ancillary roles being associated with the case and the need for attention elsewhere. Without swift feedback on IABP experiences, students have no means of gauging their level of proficiency.

## **2.6: Best Practices in Curriculum Design**

Perhaps the greatest challenge that students face when it comes to IABP content is remembering the details of their curriculum when they graduate. Since the course

material is taught prior to the halfway point of the program, IABP content must remain current in students' memories for nine months. This proves problematic, especially when the material is lightly reviewed throughout the duration of the program [29].

It has been well established that 90% of non-reinforced material is forgotten within about a week of acquiring the knowledge [30]. In fact, the retrieval of content exponentially decays over time, which is also known as transience [31]. Hermann Ebbinghaus first described this relationship between memory and time, and it is often called the Ebbinghaus forgetting curve [32, 33]. This exponential memory loss means that much of the material learned is quickly forgotten, often within days [33]. After months without review, a minimal amount of information is retained [33, 34].

Ebbinghaus went on to propose that memories could be strengthened with better memory representation featuring mnemonic techniques and frequent repetition based on recall [30]. Mnemonics help strengthen memories by increasing the memory stability and decreasing the deterioration over time [30]. When material is reviewed or re-learned, the retrievability of the memory essentially resets to the level at which the material was originally learned [29, 30]. With these two strategies in mind, students' retention of IABP material can be strengthened. By integrating mnemonics into important IABP topics and promoting frequent review of IABP content, students will be better prepared with the necessary knowledge.

When material is reviewed by students, it is important that students can comprehend the topics and relate them to their experiences [35]. Many learning styles exist among

students, which can be considered in curriculum design by incorporating mental abilities [36]. One set of mental abilities includes the following types of learning abilities: verbal comprehension, word fluency, number facility, spatial visualization, associative memory, perceptual speed, and reasoning [36]. While acknowledging these learning styles, effective review material can help students become self-directed and more proficient learners [37].

## **2.7: Problem Statement**

As suggested by Ebbinghaus, this environment of limited feedback on ancillary perfusion roles, specifically IABP operation, creates a challenging learning situation [33]. Without receiving feedback and promoting discussion, students have limited formal opportunities to review the concepts learned in their course curriculum and their retention begins to decline [30]. This is especially important when in the clinical environment because the course material was only taught in a didactic setting. Without review and recall, students' knowledge of IABP operation continues to decay [29]. It's important that students are able to graduate with the required level of skill expected, despite this decay.

In reviewing the Milwaukee School of Engineering's Master of Science in Perfusion program and feedback given by recent graduates and their employers, the curriculum devoted to intra-aortic balloon pump techniques seems inadequate to meet the expectation of employers. The goal of this thesis project is to provide substantial supplemental material that students could use to review and refresh their understanding of

IABP techniques before employment. Besides a written reference guide, additional mediums of review material are needed to engage all students. Through the use of a reference guide, an interactive video, and a self-paced evaluation, students will reinforce their knowledge about intra-aortic balloon pumps prior to entering the work force.

### 3.0: Methods

In an attempt to effect a change in graduate comfort level with the IABPs, the steps outlined in Table 2 were conducted. In brief, opportunities for additional IABP education and training were identified and instructional materials were developed to supplement the established curriculum. The materials created include a study guide, tutorial video, and self-assessment tool.

**Table 2. The Steps Performed to Develop IABP Material.**

Step 1	Reviewed current curriculum and resources used to educate current students about IABPs in the MSOE MSP program and identified opportunities to supplement IABP education.
Step 2	Reviewed graduate and employer surveys for themes related to IABP training.
Step 3	Investigated established core and clinical competencies available for IABP training.
Step 4	Developed a comprehensive written study guide and video based on current curriculum, survey findings, and established competencies. Incorporated aspects of learning preferences and mnemonics
Step 5	Developed a self-assessment tool for students to evaluate their own level of proficiency.
Step 6	Surveyed active perfusionists and current students for feedback on the developed material.

Intra-aortic balloon pump content coverage in the current MSOE curriculum was determined by reviewing notes from the Seminar on Clinical Medicine course, and the current student handbook, as well as by engaging in discussion with students and faculty. A logical order of topics was used to build on previously learned concepts, and the organization of this material was important in determining the order and presentation of

the study guide. The presentation of the study guide was mostly determined by the arrangement of material in the Seminar on Clinical Medicine course.

To determine what material was lacking in the current curriculum, the employer and graduate surveys were reviewed. As previously discussed, there were trends found in the surveys that indicated a lack of content coverage on transporting patients with IABP support, slaving off the patient monitor, and performing the initial IABP setup. In addition to the content covered in the MSOE course, these topics received special attention in the review material.

As previously discussed, Check's MSP thesis project included the identification of core and clinical competencies associated with IABP [27]. This current thesis project relied on the established core competencies, shown in Appendix D, as a basis for development of additional instructional materials. Each core competency has a section devoted to it in the study guide. Contained in these sections are details and specifics on each topic, which are shown in Table 3. With all this information gathered, the comprehensive study guide was created and is included in Appendix A.

**Table 3. Each Core Competency is Represented in Corresponding Sections of the Study Guide.**

<b>Core Competency</b>	<b>Corresponding Study Guide Sections</b>
Recognize optimal and suboptimal timing	Timing the Balloon
Interpret and troubleshoot console alarms and abnormalities	Alarms and Troubleshooting
Develop skills and knowledge enabling them to appropriately operate the IABP and identify the equipment required for the procedure	Features of Common IABPs, IABP Layout, Monitor Organization, and Slaving Off a Patient Monitor
Describe the purpose for IABP	Principle of Counterpulsation
List the indications and contraindications for use	Indications for Use and Contraindications

To facilitate students' understanding of IABP operation and to ensure that all students find the created material effective, these abilities were incorporated into the learning material through various mediums. To appeal to various learning styles, both a written document detailing IABP specifics and an audio-visual guide were made. Each one was constructed while considering these abilities. The association between each ability and the method used to appeal to each student's aptitude are shown in Table 4.

**Table 4. Each Primary Mental Ability was Represented in the Review Material in a Specific Way [36].**

<b>Primary Mental Ability</b>	<b>Medium Used in Learning Material</b>
Verbal comprehension	Audio-video guide with verbal instructions was constructed.
Word fluency	An all-inclusive written guide with detailed descriptions and instructions was created.
Number facility	Wherever applicable, numbers were used to denote variables.
Spatial visualization	Images with the IABP console were used to describe the device's layout.
Associative memory	Acronyms were used to describe important information.
Perceptual speed	The study guide was designed with significant white space to facilitate quick readers.
Reasoning	The organization of the study guide is rational and intuitive.

To supplement the study guide and to appeal to visual and audio learning styles, a video was created showing various operations of the IABP. Using a Nikon D3300, video was taken at 29 frames per second and a resolution of 1080p. Audio was taken with an audio bit rate of 129 kbps and an audio sample rate of 48 kHz. The video was shot on January 17<sup>th</sup>, 2018, and short clips were edited using Windows Movie Maker on January 18<sup>th</sup>, 2018. The 27-minute video describes topics included in the study guide using the CardioSave Hybrid IABP by Maquet as a demonstration tool. Voice-over narration was used to verbally discuss and communicate IABP technique.

In addition to the video and study guide, self-assessment material was created to help students prepare for the clinical competency exam. To assess students' ability to pass the clinical competency exam, a quiz was created. Intended as a self-assessment tool, the



quiz includes questions taken directly from the updated “IABP Objective-Based Clinical Competency Assessment” developed in a previous project [27]. This tool will help students to accurately assess their level of understanding relative to the competency exam. In addition to the competency exam, the quiz is designed to complement the study guide.

To further develop and refine the material in both the study guide and video, a survey was sent to active perfusionists and current MSOE perfusion students. It was emailed to a total of 28 individuals. The perfusionists selected were currently practicing at Aurora St. Luke’s Medical Center (ASLMC) in Milwaukee. They were selected because of their vast clinical experience with IABPs and their proximity to the education of perfusion students. Feedback was requested from students currently in the MSOE MSP program because of their recent experience with the current IABP curriculum. Both provided valuable feedback through Google Forms. Since this survey related to educational improvement of the MSOE perfusion program and was sent to only individuals within the program, no IRB approval was acquired.

## **4.0: Results**

### **4.1: Comprehensive Study Guide**

To assist in the students' review of IABP didactic and clinical material, as previously indicated, a comprehensive study guide was developed, as presented in Appendix A.

This guide to intra-aortic balloon pumps is designed to assist in the students' review of the material and to complement the material learned in the Seminar for Clinical Medicine course. Many of the topics covered are presented in the study guide with more detail than students were initially exposed to in the current curriculum. There are both didactic and clinical topics covered in detail. The didactic elements this study guide covers include the principle of counterpulsation, indications for use, contraindications, insertion techniques, and helium use. In addition, clinical topics -- such as timing the balloon, weaning and termination, troubleshooting, augmentation, slaving from patient monitors, the helium tank replacement process, and patient transport -- are covered. These topics are intended to assist the students' clinical experience with the IABP and the students' understanding of the core competencies for intra-aortic balloon pumps.

Each section in the comprehensive study guide includes valuable information for perfusion students. Table 5 shows a brief summary of each section contained in the study guide.

**Table 5. Description of Each Section of the Study Guide.**

<b>Section</b>	<b>Description</b>
Principle of Counterpulsation	Includes a description of how a balloon pump achieves counterpulsation and its effects on the cardiac cycle.
Indications for Use and Contraindications	Situations in which IABPs should and should not be used are identified.
Insertion and Operational Techniques	Insertion locations and the proper location of the catheter are described.
Timing the Balloon	Optimal timing of both inflation and deflation are described.
Augmentation and Helium Use	The term augmentation is defined, and reasons for helium use are listed.
Weaning and Termination	Two methods for weaning IABP support and catheter removal are explained.
Features of Common IABPs	<p>This section is broken into four categories which describe necessary functions of balloon pumps and effective use of them.</p> <ul style="list-style-type: none"> <li>• IABP Layout</li> <li>• Monitor Organization</li> <li>• Slaving Off a Patient Monitor</li> <li>• Alarms and Troubleshooting</li> </ul>
Traveling with the IABP	Transportation of a patient on IABP support and techniques to assist transportation are described here.

## **4.2: Clinical Video Guide**

To supplement the written material, audio-visual material was prepared to cover specific clinical requirements. With much overlap, these two tools relate to multiple types of learners and complement each other. The learning cycle will continue as new graduates

continue to review the material and gain clinical experience with balloon pumps in an effort to meet specific competencies [29].

To aid visual and audio learners, the video was made with vocal narration to convey clinical technique. The video guide includes similar content from the study guide, but some content was omitted because the main purpose of the video is to facilitate clinical technique. The video is about 27 minutes in length, and the topics covered relate to many common operations of IABPs. Table 6 shows a comparison between the content presented in the study guide and the content in the video.

**Table 6. Comparison Between Study Guide Content and Video Content.**

<b>Topic</b>	<b>Contained in Study Guide</b>	<b>Contained in Video</b>
Principle of Counterpulsation	X	
Indications for Use and Contraindications	X	
Insertion and Operational Techniques	X	X
Timing the Balloon	X	X
Augmentation and Helium Use	X	
Weaning and Termination	X	X
Features of Common IABPs	X	X
Traveling with the IABP	X	X

Although these topics are covered in the study guide, their visual representation allows for more efficient comprehension, especially by visual learners. Since this video is posted

to the YouTube channel MSOE Perfusion, it can be viewed at any time through the following link: <https://youtu.be/r0w-MWhnLtc>

#### **4.3: Evaluation/Self-Assessment**

To accompany the clinical evaluation and to further assess students or to allow students to perform a self-assessment, a quiz was constructed with the intent to gauge comprehension of the study guide content and the core competencies (Appendix B). Both the “Intra-Aortic Balloon Pump Evaluation” and the “Intra-Aortic Balloon Pump Evaluation Answer Key” are located in Appendix B and C, respectively. The questions in this quiz are designed to assess academic understanding and to accompany both the updated and current clinical competency assessments. Each question in the assessment corresponds to a skill criterion from the “Updated IABP Objective-Based Clinical Competency Assessment” (Appendix E) or the “Current MSOE MPS IABP Competency Exam” (Appendix F). Every answer to the quiz questions can be clearly found in the study guide. Additional questions were added to assess other clinical elements and scenarios. Motivated by both the clinical competency exam and study guide material, the quiz was designed to test students’ overall level of IABP technique.

With 18 short-answer questions, the quiz evaluates students’ recall of IABP material detailed in the study guide. Although the guide elaborates on each topic highlighted by the evaluation, all the answers can be easily identified. By evaluating a student’s level of understanding after reviewing the study guide, the quiz offers swift feedback to students.

If students receive positive responses on this evaluation, the clinical competency exam should be manageable, and students should feel confident in their IABP knowledge.

#### 4.4: Survey Results

To gauge the usefulness and accuracy of the created content, a survey requested feedback on the content of the study guide and video guide. The survey requested active perfusionists and current students to review the content of both the study guide and video, and then to answer questions about their effectiveness. These questions are shown in Table 7, along with the type of response requested.

**Table 7. List of Questions Contained in the Survey and the Type of Response Associated with the Question.**

<b>Question</b>	<b>Response Type</b>
Did you find the study guide helpful in reviewing IABP operation?	Multiple Choice (Yes, Maybe, or No)
Did you find the video helpful in reviewing IABP operation?	Multiple Choice (Yes, Maybe, or No)
What other content would you find helpful if included?	Open Response
What content was poorly represented?	Open Response
What review tool did you find more helpful?	Multiple Choice (Study Guide or Video Guide)
If you were to review IABP procedures in the future, what learning tool would you probably use?	Multiple Choice (Study Guide or Video Guide)
Provide any other comments and questions.	Open Response

The first two questions asked related to the usefulness of the material and allude to its overall effectiveness. These were multiple-choice questions with possible responses of “Yes,” “Maybe,” and “No.” The results can be found in Table 8.

**Table 8. The Results from Content-Based Questions.**

<b>Question</b>	<b>Yes</b>	<b>Maybe</b>	<b>No</b>
Did you find the study guide helpful in reviewing IABP operation?	92.3%	7.7%	0%
Did you find the video helpful in reviewing IABP operation?	84.6%	15.4%	0%

The questions, “What other content would you find helpful if included?,” and “What content was poorly represented?” are focused specifically on content selection and accuracy. Responses to these questions varied, but some themes emerged. The main concern was in regard to the length and organization of the study guide. Specific comments included, “The detail is nice to have for students to keep for boards prep, but something shorter would be more practical in the operating room,” and “I just think it needs to be more concise.” Additionally, there were a couple of other comments that requested more troubleshooting material. These comments included, “All the material I was expecting was thoroughly covered, but more troubleshooting tips are always beneficial,” and “Troubleshooting examples in the video pertaining to catheter kinking and balloon inflation issues.”

To gauge the effectiveness of each tool relative to the other, a couple of questions were asked: “What review tool did you find more helpful?” and “If you were to review IABP procedure in the future, what learning tool would you probably use?” These questions add value to the review materials by determining what medium participants are more responsive to. Between the video and study guide, the results are shown in Table 9.

**Table 9. Results of Questions Comparing Learning Tools.**

<b>Question</b>	<b>Video Guide</b>	<b>Study Guide</b>
What review tool did you find more helpful?	92.3%	7.7%
If you were to review IABP procedures in the future, what learning tool would you probably use?	76.9%	23.1%

The final question of the survey simply asked, “Provide any other comments and questions.” Designed as a blanket question, responses ranged widely. Most responses to this were positive feedback. Some of these comments include, “The study guide and video were both very useful because you could refer to the guide if you did not fully understand the video, and vice versa,” and “The video is nice to do from start to finish, but as a ready-reference for when someone is having issues, the study guide/manual is nice.” These comments, among others, indicated the study guide in conjunction with the video was more effective than individually. This comment stated it best: “The video does a great job of showing what the different parts of the balloon pump are and how it looks when in action and does a good job for initial training. The reference guide is a good tool for looking up answers to specific situations. Both the video and the reference guide



complement each other very well and are both valuable tools for IABP training.” These questions were designed to prompt critical evaluation of the created material for the purposes of improvement. With qualified feedback, the material’s validity and usefulness are supported, and this feedback also helped provide additional content.

All the created material, including the study guide, video, quiz, and answer key to the quiz, can be accessed through the following link:

[https://drive.google.com/open?id=1NZaRorRsVjA\\_hd2ilD9\\_VVcotUJR28ao](https://drive.google.com/open?id=1NZaRorRsVjA_hd2ilD9_VVcotUJR28ao)

This link is also in the comments section of the YouTube video.

## **5.0: Discussion**

Perfusionists have many ancillary responsibilities aside from cardiopulmonary bypass; one of these is the operation and maintenance of intra-aortic balloon pumps [5]. The goal of this thesis project was to develop learning material to assist perfusion students in the comprehension and retention of intra-aortic balloon pump technique to better qualify them for employment. This was achieved through the creation of a comprehensive study guide, tutorial video, and self-assessment tool. Together, these materials are helpful for current and future perfusion students to review and to improve their IABP technique in preparation for employment.

The survey results in response to the study guide and video were largely positive. The majority of these responses indicated both the video and study guide were helpful. In addition, comments indicated the video and study guide complemented each other well, likely because each material set supports various learning styles. Some participants of the survey showed interest in a more concise study guide. Since the guide is meant to be comprehensive, the document was designed to be more intuitively organized and to maintain a more condensed feel. Also, when viewed electronically, various software tools can be used for easier navigation and quick searches. The video has also been indexed into sections for faster topic selection when viewed on YouTube. Other comments requested additional troubleshooting material. This feedback was addressed by adding additional troubleshooting scenarios specifically regarding trigger sources. Overall, this feedback has improved the functionality of the materials while validating their accuracy and helpfulness.

A challenge faced in creating this material was effectively implementing it and encouraging more clinical experiences for students. To truly improve the intra-aortic balloon pump technique of students, additional or more effective clinical experience is needed. According to Ebbinghaus, retaining information is dependent on the frequency of recall [33]. Although simply obtaining this information provides limited benefit to students, reviewing it in combination with clinical experience should increase its utility. For students to maintain and to improve their IABP knowledge, additional review of didactic material and more clinical experience are necessary.

To follow Ebbinghaus' advice on strengthening memory retention, more frequent review of IABP material is required [29]. However, because of the MSOE MSP program's information-dense curriculum, students are currently not clinically assessed on intra-aortic balloon pump after their initial didactic assessment. Students often quickly forget what they have learned in previous courses when a new set of courses starts. It's challenging for students to focus on a previous courses' content when they are assessed on new material. After their didactic course, clinical experience with IABP is limited as a result of two main factors: few cardiac patients require IABP support, and anesthesia technicians or clinical perfusionists are the primary operators of the IABP. Acquiring more IABP experience can be challenging in this environment. Therefore, open feedback regarding IABP operation between instructors and students must be developed.

To improve the effectiveness of the limited IABP clinical experience, opportunities where students are assigned cases with patients on IABP support must be taken full advantage of. When there is a case with IABP use, the instructor and student assigned to

this case should make interaction with the IABP a priority. To utilize the infrequent exposure to IABP effectively, students should be required to be the primary operator of the IABP alongside the perfusionist or anesthesia technician during these cases. This procedure will not only refresh the student's knowledge of IABP operation, but will also provide them valuable exposure to clinical IABP use. Additional experience and review can be gained by utilizing the IABP simulator and by re-assessing students more frequently. Moreover, feedback from instructors on case evaluations will also promote IABP technique improvement.

A prior thesis project by an MSOE MSP graduate recommended quarterly competency assessments [27]. Check suggested administering clinical competency exams for all ancillary tasks, including balloon pumps, at the beginning of every quarter after the content was covered in the program's curriculum [27]. This regular assessment would start after students have finished the Seminar on Clinical Medicine course, which would mean that assessments would be administered every few months for the remainder of the program. This procedure would provide students the opportunity to review content on IABP techniques prior to assessment. The review material created in this project provides the necessary tools for students to succeed during these assessments. It would also prompt clinical faculty to make changes to the curriculum if many students show similar weaknesses in specific techniques. Increasing the frequency of IABP review and assessment will improve the overall retention of the content by students and improve their clinical competence. To date, these recommendations have not been fully implemented.

It is recommended that the new material be implemented by performing clinical competency assessments at the beginning or end of every quarter. To prepare for the assessment, didactic and clinical information can be reviewed by students using the comprehensive study guide, video, and quiz. This procedure should be executed for every graduating class, and the implementation strategy should be re-evaluated after three years. To measure the success of this material and its application, the employer and graduate surveys can be reviewed. If successful, the number of negative comments associated with IABP training should decrease from current levels -- 26% for employers and 23% for recent graduates. Collectively, these materials will help students to meet the demands of clinical competency assessments and employers' expectations, but their effectiveness will be determined by their integration into the MSP program.

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**Appendix A: Comprehensive Intra-Aortic Balloon Pump Study Guide  
for Perfusionists**

**Comprehensive Intra-Aortic Balloon Pump  
Study Guide for Perfusion Students**

by

Ryan J. Schmidt

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## **I. Principle of Counterpulsation**

The intra-aortic balloon pump works on the concept of counterpulsation. This means the balloon inflates during diastole causing volume displacement and deflates during systole causing blood to be drawn down the aorta [1]. While the balloon inflates during diastole, more blood flow is directed into the coronary arteries and therefore myocardial oxygen supply is improved [2, 3]. This has been shown to effectively treat cardiogenic shock and acute myocardial ischemia. Overall, IABP therapy reduces the workload on the heart and improves ventricular performance by decreasing afterload and preload while increasing overall cardiac output [4].

The portion of time where the balloon is filling during diastole is known as diastolic augmentation and is a measure of the balloon pump's contribution [5]. The magnitude of the effects of an IABP is dependent on a few variables: balloon volume, heart rate, and aortic compliance [4]. The balloon volume is proportional to the amount of displaced blood and its effectiveness. Heart rate and diastolic filling times are inversely proportional; faster heart rates cause less balloon augmentation [2]. Additionally, as aortic compliance increases or systemic vascular resistance decreases, the diastolic augmentation also decreases [5].

## **II. Indications for Use and Contraindications**

The main indication for the use of an intra-aortic balloon pump is to improve coronary blood flow and reduce the workload of the heart, especially in patients with coronary artery disease [6]. These indications and contraindications can be seen in Table 1 [2]. The use of an IABP is aimed at temporarily maintaining hemodynamic stability until definitive treatment or recovery occurs. IABPs are common in cases of acute myocardial infarction, because counterpulsation applies more pressure and flow into the coronary ostia during diastole[3, 7]. This limits ischemia and promotes oxygen delivery in acute myocardial infarction and other indications such as ventricular arrhythmias, cardiogenic shock, unstable angina, and cardiomyopathies [8]. Other secondary effects of IABP use include: increasing cardiac output by about 1.5 L/min, decreasing heart rate over time, decreasing pulmonary arterial pressure, decreasing systemic vascular resistance (SVR), and increasing mean arterial pressure [2]. Even though mean arterial pressure (MAP) increases, unassisted systole and unassisted diastole decrease. The increase in MAP comes from the diastolic augmentation.

In cardiac surgery, IABPs are often used to stabilize high-risk patients with acute myocardial infarction before cardiac surgery. Often the guideline for the insertion of IABP is based on an ejection fraction less than 35% [9]. Usually initiated in the cardiac catheterization laboratory and maintained through perioperative periods, IABP support is maintained until patients are stable. For cardiac surgeries with long aortic cross-clamping, preexisting myocardial dysfunction, or where severe reperfusion injury occurs, attempting to wean from cardiopulmonary bypass may result in hypotension and low

cardiac output [10]. In this scenario, IABP support can help by increasing cardiac output, increasing coronary and systemic perfusion, and improve arterial pressure [11].

A common contraindication for IABP support is aortic regurgitation because the added diastolic pressure magnifies the regurgitation [2, 6]. Aortic dissections are another common contraindication because the IABP may be inserted into the false lumen, which would cause the dissection to propagate [12]. Either in the false or true lumen, the IABP can cause extension of the dissection or a full aortic rupture with an already dissected aorta. Similarly, aortic aneurysm can be amplified with the insertion of an IABP [13]. Cardiac output will likely increase by about 1.5 L/min with an IABP, so patients requiring more flow than a IABP can provide may require a different assist device [14].

**Table 1. Indications and Contraindications for IABP Therapy are Listed [2].** Some relative contraindications can be overlooked in certain situations.

<i>Indications</i>	
Acute myocardial infarction	Refractory LV failure
Cardiogenic shock	Refractory ventricular arrhythmias
Acute MR and VSD	Cardiomyopathies
Catheterization and angioplasty	Sepsis <sup>9</sup>
Refractory unstable angina	Infants and children with complex cardiac anomalies <sup>10</sup>
Cardiac surgery	
Weaning from cardiopulmonary bypass	
<i>Contraindications</i>	
<b>Absolute</b>	<b>Relative</b>
Aortic regurgitation	Uncontrolled sepsis
Aortic dissection	Abdominal aortic aneurysm
Chronic end-stage heart disease with no anticipation of recovery	Tachyarrhythmias
Aortic stents	Severe peripheral vascular disease
	Major arterial reconstruction surgery

Improper placement of the balloon can also have unintended consequences. If the balloon is seated over the left subclavian, the left arm will become hypoperfused [13, 15].

Similarly, with the renal arteries, the kidneys will have reduced blood flow if the balloon is placed over them [16, 17]. This will be evident by dramatically reduced urine output. If placed correctly, renal blood flow can increase by up to 25% [2]. Correct placement of the balloon catheter is critical to its effectiveness.

Mechanical damage from the intra-aortic balloon (IAB) can have significant hematological effects. Hemolysis caused by the mechanical forces of the balloon can reduce hemoglobin by up to 5% [2]. This mechanical damage can also cause thrombocytopenia. Other complications associated with IABP support include compartment syndrome, aortic dissection, infection, balloon rupture/gas embolus, malpositioning causing cerebral compromise, and cardiac Tamponade [2, 18].

### **III. Insertion and Operational Techniques**

The balloon itself is made of polyethylene and is inflated with Helium. Due to its low density, Helium transfers rapidly, and it's easily absorbed into blood [2]. The balloon volume should be determined by the patient's height, and the diameter of the balloon should not exceed 80-90% of the patient's thoracic aorta [2]. When fully inflated, the balloon should not fully occlude the aorta; this limits hemolysis. The recommended

balloon volume is based on patient's height, and are shown in Table 2 [2, 15]. Balloon diameters are predetermined by the manufacturers.

**Table 2. Recommended Balloon Catheter Sizes Relative to Patient Height [2, 15].** Balloon catheter sizes are determined by the filling volume of the balloon.

Patient Height	Balloon Volume
<152 cm	25 cc
152 – 163 cm	34 cc
164 – 183 cm	40 cc
>183 cm	50 cc

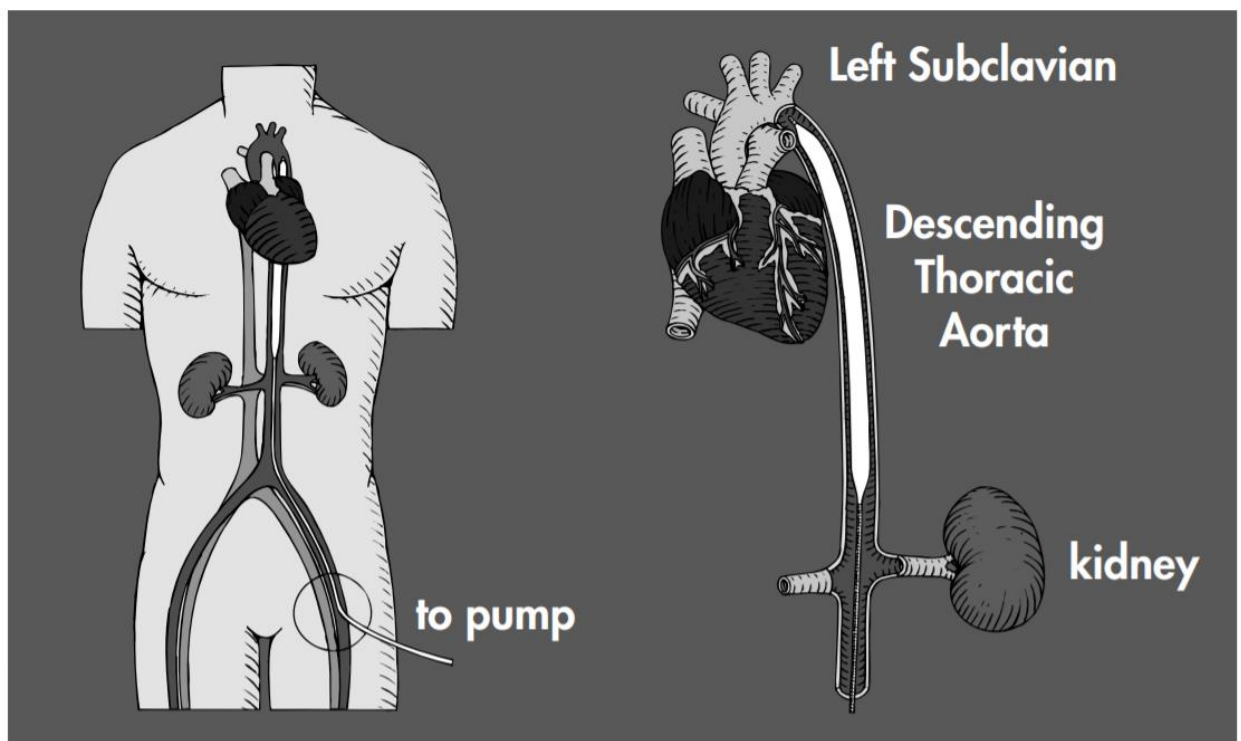
Most often the balloon is inserted through the femoral artery and seated in the mid-thoracic aorta, distal to the left subclavian and proximal to the renal arteries [16].

Alternative insertion sites include subclavian, axillary, brachial, or iliac arteries [19]. The catheter is surgically inserted usually using the modified Seldinger technique [1].

Advancing the catheter is usually done under fluoroscopic guidance, or placement can be confirmed intraoperatively with a transesophageal echocardiography [20]. The tip of the catheter should be placed 2 to 3 cm distal to the origin of the left subclavian [15].

Placement of the balloon is critical to proper blood flow through the aortic head vessels and renal arteries [21]. If the balloon is placed too distal in the aorta, blood flow to the kidneys will be compromised [17]. This is evident by significantly reduced urine output.

Similarly, if the balloon is placed too proximal, blood flow through the head vessels will be compromised [1]. This will be evident by low cerebral saturations, especially on the left side. Figure 1 shows the proper placement of the balloon catheter in the aorta relative to the anatomical landmarks previously described [1].



**Figure 1. Intra-Aortic Balloon Placement in the Aorta Utilizing Femoral Catheritization [1].** Notice the balloon is distal to the left subclavian and proximal to the kidneys.

## **IV. Timing the Balloon**

Timing the inflation and deflation of the balloon is critical to effectively reducing the workload on the heart [4]. In fact, inappropriate timing can actually increase the workload on the heart and exacerbate symptoms [22]. The IABP needs an input from the patient's cardiac cycle to determine when to inflate and deflate the balloon; this input is called a trigger. The most common triggers used are the ECG waveform and the arterial pressure waveform [4]. The balloon inflates at the beginning of diastole, which corresponds to the middle of the T-wave [1]. Subsequently, the balloon deflates with the onset of systole, which corresponds with the peak of the QRS complex [5]. If the ECG has cardiac arrhythmias, electrical interference, or there is poor EKG signal, the balloon inflation and deflation will become erratic and ineffective [23]. This is especially true in the operating room when the Bovie or other cauterizer device is in use, as the electrical interference disrupts the ECG signal. It's recommended to switch triggers when there is an abnormal ECG.

An alternative trigger is the arterial pressure waveform. The balloon inflates after the aortic valve closes, which corresponds with the dicrotic notch. Similarly, the balloon deflates just before the aortic valve opens. This matches with the upstroke of the arterial waveform, just before systole. Using the arterial pressure waveform as a trigger should be considered when the ECG is abnormal or in an operating room setting when electrical interference is present. There are four possible errors in timing an IABP [4]:

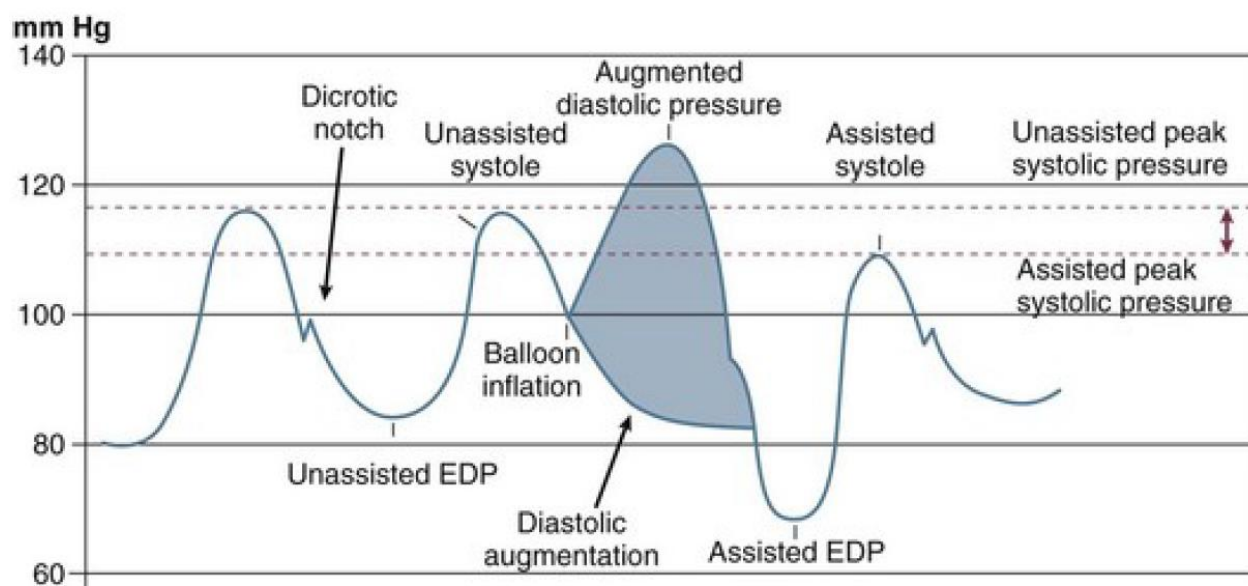
- Early inflation – inflation of the balloon occurs before the aortic valve closes



- Late inflation – inflation of the balloon well after the aortic valve closure
- Early deflation – premature deflation of the balloon during diastole
- Late deflation – deflation of the balloon after the start of systole

Early inflation and late deflation are the most detrimental of the errors. These timing errors increase the work load of the heart and can cause further damage to the myocardium [4]. When timing, it is better to err on the side of later inflation and earlier deflation. Although these errors decrease the effectiveness of the balloon, they are not harmful. To remember the safest starting position when manually timing a balloon, use the mnemonic LIED (**L**ate **I**nflation, **E**arly **D**eflation).

In Figure 2, the optimal timing of the IABP is shown in an arterial pressure waveform [5]. Notice the peak after unassisted systole; this second peak is diastolic augmentation and is a result of the balloon inflation. In addition, the assisted end diastolic pressure is lower than the unassisted diastolic pressure. This is a result of balloon deflation.



**Figure 2. Arterial Pressure Waveform with Optimal Inflation and Deflation of an IABP [5].**

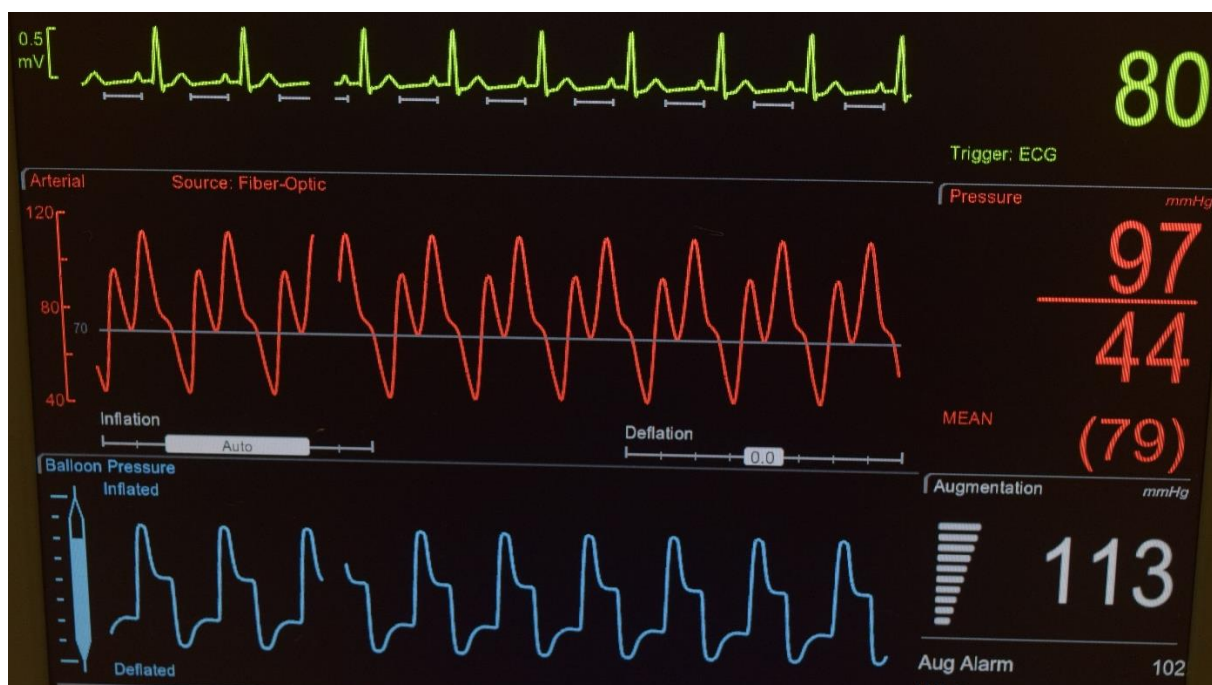
The arterial blood pressure, either measured off the balloon catheter or by a pressure transducer, is the most effective way of coordinating the balloon timing. Inflation of the balloon should occur at the dicrotic notch, which is shown in Figure 2. It's easiest to start timing the inflation first. When timing the inflation of the balloon, work from late inflation toward the dicrotic notch. As inflation is adjusted earlier, the diastolic augmentation will increase and move closer to the dicrotic notch. Stop moving the inflation earlier when the diastolic augmentation starts at the dicrotic notch.

Timing the deflation of the balloon should be done by starting with early deflation and working toward the lowest end diastolic pressure. Moving deflation later and later will decrease the end diastolic pressure until late deflation is achieved and the end diastolic pressure increases. After the end diastolic pressure starts to increase, move deflation

slightly earlier. The optimal deflation is where the assisted end diastolic pressure is the lowest.

## **V. Augmentation and Helium Use**

The term augmentation describes the change caused by the IABP and relates to the filling volume of the balloon catheter. The augmentation can be adjusted by the filling pressure of the balloon [24]. When the balloon augmentation is set at 100%, the assisted diastolic augmentation will be at its maximum. Most IABP consoles have the ability to adjust the level of augmentation to fit the patient's needs. Figure 3 illustrates the relationship between arterial pressure (red) and balloon augmentation (blue).



**Figure 3. The Arterial Blood Pressure Trace in Red is Augmented by the Intra-Aortic Balloon Inflation and Deflation Every Cardiac Cycle. The augmentation trace in blue can be compared to the augmentation in the pressure trace. The augmentation is set to 100%, and the balloon frequency is 1:1.**

In general, the diastolic augmentation is a measure of the effectiveness of the IABP, and there are several factors that can affect this. Physiologically, the heart rate and rhythm can affect the diastolic augmentation [24]. When the heart has strong contractions and adequate coronary blood flow, the diastolic augmentation will increase due to the contributions of the native heart. Additionally, the compliance or stretch of the aorta affects the diastolic augmentation [25]. Often, compliance of major arteries decreases with age. With old age, vessels become less compliant and stiffer [26]. Counterpulsation relies on limited volume changes with dramatic changes in pressure to displace the blood volume in the aorta [25]. There are also settings on the IABP that can affect the diastolic augmentation such as the filling volume either by the size of balloon catheter or the

augmentation level [5]. The more volume displaced by the balloon catheter, the greater the diastolic augmentation and the more effective the IABP will be [15].

Helium gas is shuttled between the balloon and the pump, causing the inflation and deflation. Because of its low viscosity, helium is quickly transported with little turbulent flow [2]. This is shown by the steep slope of the balloon augmentation trace in Figure 3. In addition, helium is absorbed readily into blood. In the event of a balloon leak or rupture, the risk of gaseous emboli from the helium is low.

## **VI. Weaning and Termination**

Once the patient's condition has improved and become more stable, weaning from IABP support can be considered. Prior to weaning from the IABP, wean pharmacological support such as inotropes, vasopressors, and vasoactive drugs [27]. If the patient is on mechanical ventilation, this too should be coordinated. Some guideline indications showing a patient is ready for IABP removal include [27]:

- Cardiac index  $> 2.2\text{-}2.5 \text{ L/min/m}^2$
- MAP  $> 65\text{mmHg}$
- Stable heart rate and rhythm

Weaning from the IABP can be done by frequency or augmentation reduction. The frequency of IABP counterpulsation is described by the number of cardiac cycles per balloon inflation cycle. A frequency of 1:1 means for every heartbeat the balloon inflates and deflates, while a frequency of 1:2 means every other heart beat is assisted. Setting the frequency to 1:2 will allow the clinicians to assess what an unassisted cardiac cycle looks like. This can be useful in timing and assessing hemodynamic stability [28].

To wean from the IABP, decreasing frequency can help gradually allow the heart to pump independently. Monitor patient hemodynamics throughout frequency reductions. When it has been determined appropriate to wean a patient off IABP support, reduce the balloon frequency from 1:1 to 1:2. If the patient's hemodynamics remain constant after a frequency reduction for a considerable amount of time, continue reducing the frequency [28]. Spending hours between frequency reductions is not unusual. If at any point during the weaning process, the patient's hemodynamics begin to change dramatically and the patient begins to become unstable, full IABP support should be resumed [29]. In this case, the patient may not be ready to withdraw support. When the balloon is in the lowest frequency, usually 1:3, the balloon can be put on standby. Once the balloon is no longer pulsing, the chance of clot formation increases, and the balloon should be removed.

Weaning by reducing the augmentation or volume reduction weaning are similar in concept. In this method, the augmentation or volume of helium used to fill the balloon is gradually reduced. Most IABP systems allow the clinician to reduce the volume in 10% increments with a maximum augmentation volume of 100% and a minimum of 0%.

While on full IABP support, the augmentation should be set to 100% and a frequency of

1:1. To gradually wean, reduce the augmentation in 20% increments, and assess the patient's hemodynamics for 15 to 30 minutes between augmentation reductions [28]. Before removing the balloon catheter, confirm the patient's coagulation status. To prevent uncontrollable bleeding, no heparin should be circulating, and the patient's INR/PT or ACT should be within normal ranges [27].

Weaning by volume reduction is considered by some to be a more effective means of weaning patients [29]. Examinations of hemodynamic outcomes when weaning is done by frequency reduction have found greater hemodynamic suppression when compared to volume reduction weaning [29]. This is likely because a reduction in frequency could be considered complete IABP for the cardiac cycles without counterpulsation [29]. Also, volume reductions can be made much more gradually. There are ten possible levels of reduction in augmentation versus just three levels in frequency reductions. These considerations aside, both methods of weaning have been shown to be effective if done gradually.

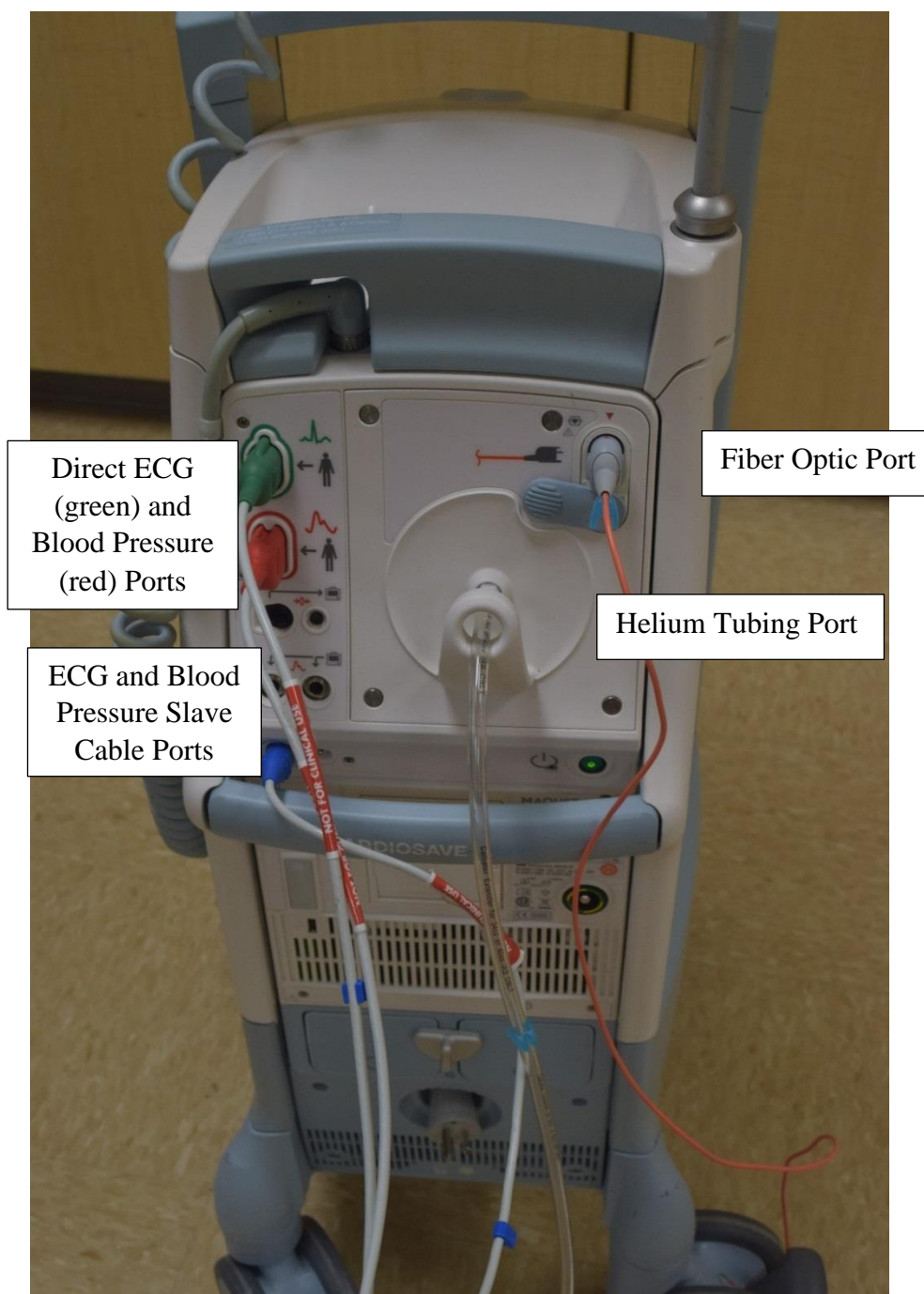
## **VII. Features of Common IABPs**

For the purpose of this review guide, the CardioSave Hybrid Intra-Aortic Balloon Pump by Maquet will be used to discuss the features of many IABP systems. This is a commonly used balloon pump and is similar in design to many others.

### **a. IABP Layout**

Most IABP consoles, including the CardioSave, are designed with the connecting ports in the back of the device. Figure 4 shows the back of the CardioSave IABP with various connections made. The configuration shown is sufficient to visualize the traces and start the balloon. Although other connections can be made, the setup shown in Figure 4 is common.





**Figure 4. View of the Back of a CardioSave Hybrid.** The direct ECG and blood pressure monitoring ports are located in the upper left corner. In this image, slave cables are not attached, but they would be placed in the ports below the direct monitoring ports. The orange fiber optic cable is located in the upper right corner of the console. Below this is the port for the helium tubing. The tubing should be threaded through the holder to prevent unwanted disconnection. The blue port and cable is only used for the simulator, which is never used when the IABP is connected to a patient.

In the upper left corner of the console are the direct ECG and blood pressure monitoring lines. These are only used if the ECG and blood pressure are being measured directly off the IABP. The green port is for the ECG monitoring line, and the red port is for the blood pressure monitoring line. Below these ports are the slave cable ports. These are only used if the ECG and blood pressure are being taken off the patient's monitor or from another source. In general, it is best practice to use the direct monitoring lines, unless ECG and arterial blood pressure are already being monitored.

The orange fiber optic cable and helium gas line will have to be passed from the sterile field. In the upper right corner is the fiber optic port. This measures blood pressure directly from the tip of the balloon catheter in the aorta. The helium tubing should be passed through the circular holder and then inserted into the port. This guard helps prevent the tubing from unintentionally being disconnected. Be sure this tubing is positioned in such a way as to prevent kinks and excessive tension. Keeping all cords and tubing organized and strategically placed prevents unintended disconnections and aids in troubleshooting.

The power button is located just above the blue handle on the back of the console. A green light will illuminate the button when the device is powered on. Below the blue handle are two batteries. The level of charge on these batteries can be seen by pressing the button on them. The level of charge on each battery is indicated by the number of lights illuminated. When powered by batteries, the IABP will use one battery at a time. Once one battery's charge is depleted, it will automatically switch to the other battery. Each battery can be removed by rotating the grey semi-circular knob. Only one battery

can be removed at a time. There is a retractable power cord located below the batteries. The batteries automatically recharge when the power cord is plugged in. It is recommended to use the power cord whenever an outlet is within the cord's reach, leaving the batteries fully charged.

#### **b. Monitor Organization**

The CardioSave Hybrid has two screens, an upper and lower. Both are shown in Figure 5. The upper screen is not a touchscreen and displays the patient's ECG and blood pressure. The display shown in Figure 5 is after the ECG and pressure monitoring lines have been connected and the balloon pump is started. It shows typical IABP settings with a frequency of 1:1 and 100% augmentation.

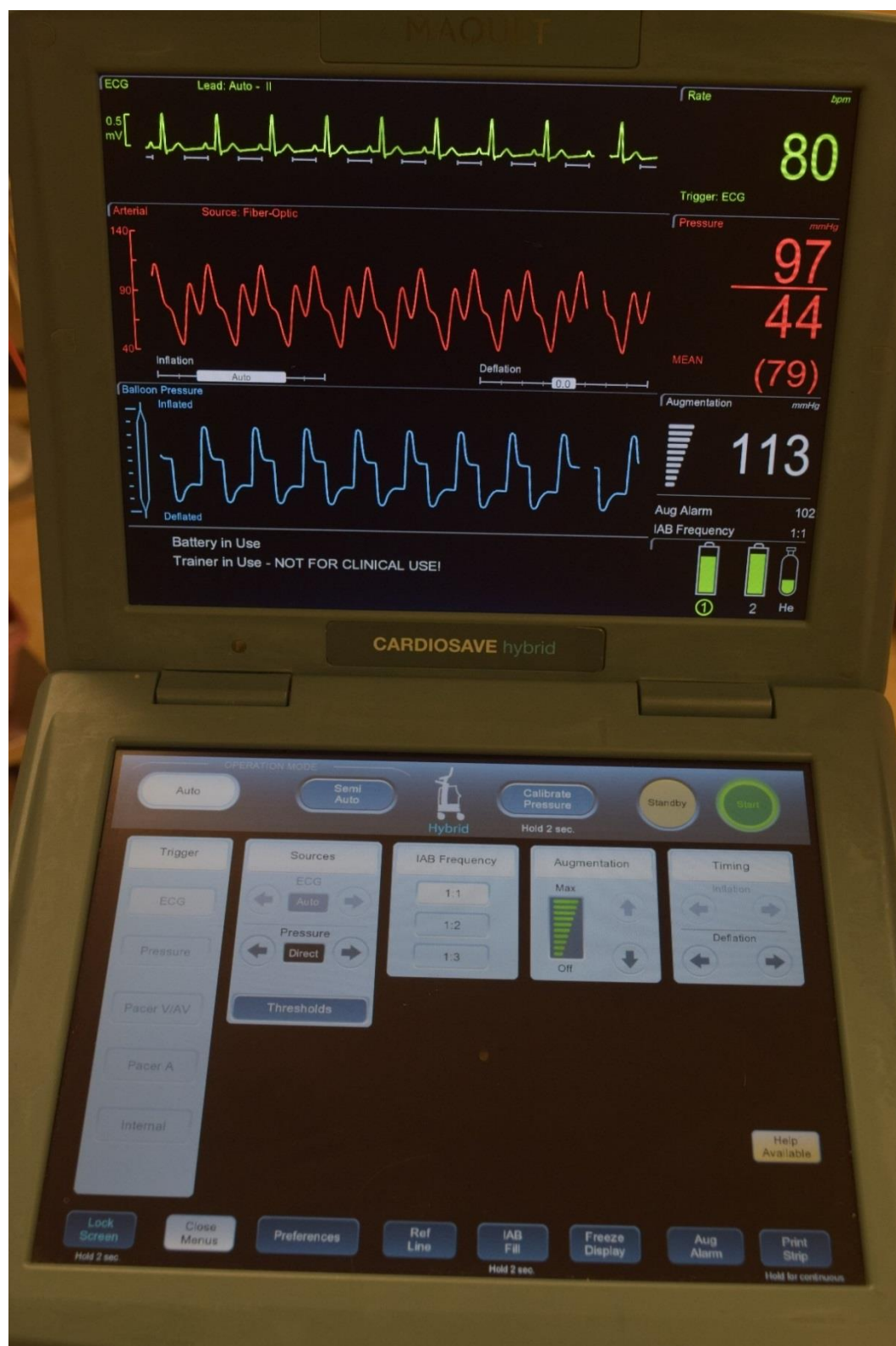


Figure 5. The CardioSave's Monitor is Divided into an Upper and Lower Screen. Both are shown here.

The green trace on the top of the screen is the patient's ECG, and the green number to the right is the patient's heart rate. Below the ECG trace is the arterial blood pressure trace, in red. To the right of the pressure trace is the systolic and diastolic pressures with the mean in parentheses below that. When in a frequency of 1:2 or 1:3, both the systolic and diastolic pressures will divide into assisted and unassisted numbers. The patient's monitor will likely be unable to recognize the difference between assisted and unassisted pressures and report the highest pressure it measures as systolic and the lowest as diastolic. The mean will stay the same and should always match the mean pressure on the patient's monitor. Just below the pressure trace are the toggle bars for balloon inflation and deflation. These bars can be adjusted in the lower screen. When the inflation bar reads, "Auto," the balloon timing is in automatic mode. To adjust the balloon's inflation, it must be in semi-auto mode. This adjustment can be made in the lower screen.

Below the red pressure trace, the balloon augmentation trace is in blue. The blue bar to the left of the trace represents the balloon filling. The white bars to the right of the trace represent the percentage of augmentation. The number of filled bars represents the percentage of balloon filling. The number to the right of these bars is augmentation pressure. The augmentation alarm level is shown below this. When the augmentation alarm level is greater than the balloon's augmentation pressure, an alarm will chime. The balloon frequency is also shown. Below the augmentation trace, alarms and notifications will appear. In the lower right corner, the battery charge and helium tank level appear. When the IABP is running on batteries, the battery symbols will appear green, and when

plugged into a wall outlet, the batteries will be grayed out and an outlet plug symbol will appear.

The lower monitor is a touchscreen, and is where all balloon pump parameters can be altered. In the upper left corner, the balloon can be switched from auto mode to semi-auto mode with the two corresponding buttons. The button in the middle of the top row labeled, “Calibrate Pressure,” is used for calibrating the pressure transducer. Be sure the transducer is open to atmosphere before calibrating. In the upper right corner are the start and stand-by buttons. The start button will begin inflating and deflating the balloon at the current specified parameters. The standby button will pause the balloon. These buttons will be outlined when they have been selected. Some operations will automatically switch the balloon into standby, requiring it to be manually started.

The menus in the middle of the screen can be closed and opened by the button second from the left in the bottom row. These menus allow the user to adjust the balloon parameters. On the left is the list of possible triggers. To the right of this are the possible trigger sources. ECG sources can be adjusted by lead, and the pressure source can be adjusted between internal and external depending on the monitoring lines placed. External pressure source refers to the slaved pressure trace off the patient monitor. When in auto mode, the ECG trigger will be selected and a lead will automatically be assigned.

The middle menu, “IAB Frequency,” allows the user to adjust the frequency of the balloon’s pulsation. Three frequency options are available, 1:1, 1:2, and 1:3. The panel to the right can be used to adjust the augmentation level of the balloon. The maximum

augmentation is 100%, and the minimum is 0% or off. Each bar represents a 10% increment change in augmentation. The far right panel can be used to adjust the balloon timing. When in auto mode, only the deflation can be adjusted. When changing the timing, the toggles in the middle of the upper screen will move accordingly.

The yellow, “Help Available” button prompts a menu that describes recent alarms and provides possible steps to resolve the issue. In the lower left corner is the lock/unlock screen button. Locking the screen prevents unintentional tampering with the IABP parameters. The preferences button brings up another menu set which allows the user to adjust various preferences such as audio settings. The “Ref Line” button places a grey reference line on the blood pressure trace. This can be moved up and down to help time inflation. “IAB Fill” performs an auto fill. This is automatically performed about every two hours, and it does consume helium. The “Freeze Display” button freezes the upper screen; the traces will no longer refresh when this button is pressed. The augmentation alarm button allows the operator to change the set point for the augmentation alarm. To print the ECG trace, pressure trace, and IABP parameters, press the “Print Strip” button. The paper will be printed out the back of the balloon pump console.

### **c. Slaving Off a Patient Monitor**

Most common IABP consoles have the ability to use the balloon pump console and/or the patient monitor to acquire ECG and/or arterial blood pressure signals. If the patient does not currently have a dedicated monitor, the pressure and ECG traces can be measured

from the IABP directly. The arterial blood pressure can be measured using the orange fiber optic cable. This measures arterial blood pressure in the aorta on the tip of the balloon catheter. ECG can be measured with electrode leads connected directly to the balloon pump console using a five lead set of cables connected to electrodes on the patient. Alternatively, if the patient has a monitor, both pressure and ECG can be slaved off the patient monitor using slave cables. These cables are connected to the back of the IABP console in their respective ports, shown in Figure 4, and the other end is connected to either the echocardiography machine or the patient monitoring system. In this scenario, the IABP uses the same ECG and pressure source as the monitor. As a trigger source these are slightly delayed from the actual waveform due to the distance the signal must travel. Although seemingly insignificant, this can disrupt the timing of automated balloon inflation and deflation. It's also possible to display the blood pressure trace measured from the tip of the balloon catheter onto the patient monitor. This can be useful when in the operating room when another pressure source is needed. In any configuration, it is important to understand the source and connection of each signal for troubleshooting purposes.

#### **d. Alarms and Troubleshooting**

The following is a list of possible alarms and/or situations that require attention. Different balloon pump manufacturers have various ways of describing these alarms, but the wording of each alarm will be similar to the following. These alarms simply draw



attention to possible unwanted situations; it is up to the operator to troubleshoot and resolve the issues.

### **1. *Loss of Trigger Alarm:***

This alarm suggests the IABP can no longer detect the trigger it was using to time the inflation and deflation of the balloon. Common causes for this alarm include ECG or pressure monitoring line disconnections, electrical interference, and loss of adequate pressure wave form or ECG signal. Under normal circumstances, the most convenient trigger is ECG, but if using the pressure trace as a trigger is necessary, use the pressure off the end of the balloon or the direct pressure trigger source. This pressure source on the tip of the balloon catheter is only available when using balloon catheters with fiber optic cables, which have an orange fiber optic cord relaying the pressure to the IABP console. Using a pressure trace off the monitor via slave cables can result in a lag time, delaying the balloon timing. If the loss of trigger alarm appears check the following:

- Normal ECG trace, no electrical interference from Bovie or other cautery device
- Placement/contact of ECG electrodes, the electrodes should be replaced if adherence/contact is inadequate
- ECG cable connection
- Choose an alternate ECG lead
- Switch to pressure trigger

## ***2. Loss of Pressure Trace/Loss of Pressure Trigger:***

The pressure trace can be taken from multiple locations. As stated earlier, balloon catheters with fiber optic cables measure the pressure off the tip of the balloon catheter. This is the most accurate and direct method of measuring arterial pressure. If the balloon catheter does not contain a fiber optic cable, a pressure transducer is likely needed. Either the transducer is included with the balloon catheter or it's being used for the monitor pressure trace. When slaving the pressure trace from the monitor using slave cables, the signal must travel further and can disrupt the balloon timing. In any of these situations, check the following to troubleshoot a loss of pressure trace alarm:

- Pressure transducer is flushed and zeroed properly
- Transducer is level with patient
- Pressure bag is inflated to 300 mmHg (if required)
- Slave cables are connected properly
- Triggering can be switched to direct or external pressure source (opposite of current)
- Trigger source can be switched to ECG

### **3. *Rapid Gas Loss:***

A rapid gas loss alarm refers to a loss in helium gas likely caused by a leak or poor connection. Helium gas is shuttled back and forth from the balloon to the IABP console through the clear tubing causing the inflation and deflation. When this alarm appears, check the following:

- Connection of/leaks in the clear catheter tubing, especially the connection in the back of the balloon pump
- After a rapid gas loss, check the helium tank level

### **4. *Augmentation Alarm:***

The augmentation alarm chimes when the augmentation level alarm is set higher than the augmentation pressure. To eliminate this alarm, the augmentation set limit can be adjusted to be less than the augmentation pressure. On the CardioSave IABP, this parameter can be changed in the lower right corner with the button labeled “Aug Alarm.” When this alarm appears, check that the balloon catheter and helium lines are not obstructed or kinked.

### **5. *Blood Detected:***

This alarm means the balloon has a leak and blood is filling the balloon and helium line. The blood may be visible in the tubing. It is important to stop the balloon pulsation before blood reaches the IABP console. If blood does reach the console, the pump should be inspected by the manufacture before being used again. When blood is spotted inside the catheter tubing, notify the patient's physician, as a new balloon catheter will need to be placed.

### **6. *Auto Fill Failure:***

Auto fill procedures are usually automatically conducted when the IABP is turned on and about every two hours thereafter. This procedure replaces the helium in the balloon and tubing with fresh helium from the tank. Depending on the size of the balloon, this can use up to 200 cc of helium. When the low helium alarm sounds, there is enough helium left to last up to 48 hours. If the auto fill function is conducted manually, it will deplete the helium tank more rapidly. Replacing the helium tank is not urgent but should be done in a timely manner. Check the following when this alarm sounds:

- Helium tank level, replace if necessary. Instructions for replacing tank differ based on brand of IABP but should be listed in IABP manual.
- Conduct manual auto fill to check balloon filling.

- A manual auto fill can be performed on the CardioSave IABP by pressing and holding for two seconds the “IAB Fill” button. This button is located in the bottom row on the lower screen.

### ***7. Low Helium Level:***

The helium level alarm indicates that the helium tank level is low. After this alarm appears, there is still about 48 hours of use, providing the operator does not perform manual auto-fills. Auto-fills are automatically performed every two hours, and when the low-level helium alarm is triggered, the helium tank has about 24 auto-fills available. Despite this buffer, it is recommended to change the helium tank as soon as it is convenient. In the CardioSave Hybrid IABP, the helium level can be seen both on the upper monitor in the lower right corner and below the monitor itself. This is shown in the figures below.



**Figure 6. The Helium Tank Level is Indicated by the Helium Tank Symbol in the Lower Right Corner of the Upper Monitor. The helium tank symbol is circled in red.**



**Figure 7. In Addition to the Upper Monitor, the Helium Level can be Indicated by the Needle Gauge Below the Monitor on the IABP Console. This gauge is circled in red.**

The following are step by step instructions on how to replace the helium tank on the CardioSave Hybrid:

1. The helium tank is located behind the lower panel on the left side of the IABP console. This blue panel has a helium tank symbol on it and can easily be removed. Behind the panel, the helium tank is attached to a pullout shelf. The helium tank can slide all the way out. The image below shows the helium tank completely pulled out.

2. Before the helium tank can be removed, the helium supply to the balloon pump must be shut off. To accomplish this, remove the key, which is attached by a chain, from its holder. Slide the key all the way onto the end of the tank and tighten by turning the key clockwise.
3. Now that the helium supply is turned off, the tank can be removed. Unscrew the retaining screw on top of the tank by turning it counter-clockwise. It does not need to be removed all the way. The tank will slide out to the right when it is sufficiently loosened.
4. Place the new tank in the holder with the same orientation as the old tank. Be sure it is slid in the holder all the way, then tighten the retaining screw back down onto the tank by turning it clockwise.
5. Once the tank is secured, the helium supply can be reopened. Use the key to open it by turning counter-clockwise. A few rotations are sufficient.
6. Slide the tank back into place and reattach the side panel.
7. Double check to confirm the new tank is full and open by reading the helium level gauge.





**Figure 8.** This is a View of the Lower Left Side of the CardioSave Hybrid IABP by Maquet. The lower left panel is removed, exposing the helium tank. The tank is then slid out to be removed.

## VIII. Traveling with the IABP

Transporting a patient on IABP support is risky and should not be conducted unless absolutely necessary [30]. However, there are many situations when it is required. There are precautions that can be made to reduce the risk of transportation and certain features of many IABP consoles that can assist in transportation [31]. There are four principles that are recommended for safe transportation of patients on IABP support [32]:

1. Transport personnel should be familiar and comfortable with IABP console function and be capable of handling various issues that could arise.
2. Patients must be stable prior to transporting them.
3. Transferring the patient should require minimal interruption of IABP support.
4. Transport personnel should be familiar with the patient's medical history and current situation.

Before transporting a patient on IABP support, be sure to communicate with the destination to ensure they are aware of your arrival and have the necessary equipment in place. All the patient's important chart information should be available to the destination. This includes the patient's status and balloon pump parameters. IABP frequency, augmentation, catheter size, and placement position should be communicated and accessible to the destination. Also, communicate the equipment currently being used. This includes the type of IABP and balloon catheter. Communicate with the destination the equipment plan. For example, will the patient remain on the IABP they are currently on or will the IABP be replaced with a console when they arrive at their destination? If switching IABP consoles, be sure all the required connectors are available. These considerations should be made with foresight and time to make adjustments as needed.

When preparing to transport a patient on an IABP, it is important that all equipment that could be needed is brought. This may include an extra set of charged batteries, a helium tank, and an extra set of ECG leads and electrodes. In fact, it might be beneficial to replace the patient's current ECG electrodes with new ones and secure them in place with tape. The movement of the patient throughout transportation can cause poorly adhered

electrodes to lose connection. If the patient is using the CardioSave by Maquet, the balloon pump console can be made smaller by removing the console from its housing. This dramatically reduces the size of the IABP for easier transportation. When this is done, there is no longer an outlet plug to run the balloon pump without battery power. However, Maquet does make an attachment that replaces one battery with a corded outlet plug, leaving one battery. When transporting a patient this way, be sure all the necessary batteries and outlet plugs are available.

When transporting patients with IABP support often, it may be beneficial to develop standard work, a written procedure. This may include a checklist of equipment and certain recommended procedures. This will keep best practices consistent and reduce forgotten tasks.

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## Appendix B: Intra-Aortic Balloon Pump Evaluation

## Intra-Aortic Balloon Pump Evaluation

The purpose of this evaluation is to test the knowledge of perfusion students, current perfusionists, and other healthcare professionals on the subject of IABP use and indications. Briefly answer each question.

1. List four indications for the use of an IABP.
2. List four contraindications for the use of an IABP.







12. After placing the IABP, you notice the patient has significantly decreased urine output. What might this tell you about the balloon placement?

13. Your patient is 6' 0" (183 cm), what size balloon catheter should you use?

14. You are a perfusionist in charge of both the IABP and heart-lung machine. At what point(s) throughout the operation must you stop the IABP? Should the patient be heparinized or not when stopping the IABP?

15. Describe the anticoagulation status of the patient when removing a balloon catheter.

16. Describe one of the ways to wean your patient from an IABP.

17. What's the best trigger in normal circumstances?

18. What should be checked if a “Rapid Gas Loss” alarm appears?

## **Appendix C: Intra-Aortic Balloon Pump Evaluation Answer Key**

### **Intra-Aortic Balloon Pump Evaluation Answer Key**

The purpose of this evaluation is to test the knowledge of perfusion students, current perfusionists, and other healthcare professionals on the subject of IABP use and indications. Briefly answer each question.

1. List four indications for the use of an IABP.

*Acute myocardial infarction, cardiogenic shock, acute VSD, catheterization/angioplasty, refractory unstable angina, refractory LV failure, refractory ventricular arrhythmias, cardiomyopathies, sepsis, and some congenital defects*

2. List four contraindications for the use of an IABP.

*Aortic regurgitation, aortic dissection, chronic end-stage heart disease with no anticipation of recovery, aortic stents, uncontrolled sepsis, aortic aneurysm, tachyarrhythmias, severe peripheral vascular disease, major arterial reconstruction surgery*



3. Explain physiological effects of IABP on the cardiac cycle.

*Over time IABP can have the following physiological effects: increased cardiac output by about 1.5 L/min, decreasing heart rate over time, decreasing pulmonary arterial pressure, decreasing SVR, and increasing mean arterial pressure.*

4. Identify where in the aorta the balloon and the tip of the balloon should be placed.

*The tip of the catheter should be 2 to 3 cm distal to the origin of the left subclavian.*

*Placement of the balloon is critical to proper blood flow through the aortic head vessels and renal arteries.*

5. List seven potential complications of IABP insertion.

*Complications associated with IABP support include thrombocytopenia, compartment syndrome, aortic dissection, infection, balloon rupture/gas embolus, malpositioning causing cerebral compromise, and cardiac Tamponade.*

6. What is the meaning of augmentation?

*The term augmentation describes the change caused by the IABP and relates to the filling volume of the balloon catheter.*

7. Explain the physiological impact of: early inflation, early deflation, late inflation, and late deflation. What is the safest situation for the patient?

*Early inflation – inflation of the balloon occurs before the aortic valve closes*

*Late inflation – inflation of the balloon well after the aortic valve closure*

*Early deflation – premature deflation of the balloon during diastole*

*Late deflation – deflation of the balloon after the start of systole*

*Early inflation and late deflation are the most detrimental of the errors. These timing errors increase the workload of the heart and can cause further damage to the myocardium. When timing, it is better to err on the side of later inflation and early deflation. Although these errors decrease the effectiveness of the balloon, they are not harmful.*

8. Name three factors that affect diastolic augmentation.

*Compliance of the aorta, size of the balloon catheter, and augmentation level setting*

9. Explain how the IABP should be timed to inflate and deflate.

*The balloon should inflate at the dicrotic notch on the pressure waveform, and the balloon should deflate such that the end-diastolic pressure is the lowest pressure possible. The timing of the inflating and deflation should be adjusted to accommodate these criteria.*

10. Explain a complication of catheter immobility.

*When the catheter is immobile or the balloon is not inflating, clots can form on the catheter and form emboli.*

11. As a perfusionist, you notice the patient's cerebral head saturations have significantly diminished since the insertion of an IABP, especially on the left side.

What could be causing this in regard to IABP placement?

*The balloon catheter could be placed too proximal, diminishing blood supply to head vessels. The tip of the catheter should be 2 to 3 cm distal to the origin of the left subclavian.*

12. After placing the IABP, you notice the patient has significantly decreased urine output. What might this tell you about the balloon placement?

*The balloon catheter could be placed too distal, diminishing blood supply to the renal arteries. The tip of the catheter should be 2 to 3 cm distal to the origin of the left subclavian.*

13. Your patient is 6' 0" (183 cm), what size balloon catheter should you use?

*Use a 50 cc balloon catheter.*

14. You are a perfusionist in charge of both the IABP and heart-lung machine. At what point(s) throughout the operation must you stop the IABP? Should the patient be heparinized or not when stopping the IABP?

*The balloon should be stopped/put on standby when the surgeon cannulates the aorta and when the aortic cannula is removed. The patient should be heparinized when the balloon is paused to prevent clotting.*

15. Describe the anticoagulation status of the patient when removing a balloon catheter.

*When removing an IABP, the patient should have no heparin circulating. Protamine should be given and the ACT should be normal.*

16. Describe one of the ways to wean your patient from an IABP.

*Prior to weaning, the patient should be hemodynamically stable. Some guidelines for this include:  $CI > 2.2 - 2.5 \text{ L/min/m}^2$ ,  $MAP > 65 \text{ mmHg}$ , stable heart rate and rhythm. To wean from the IABP adjust the frequency from 1:1 to 1:2. Monitor the patient's hemodynamics closely. If no changes occur after 30 min, reduce the frequency further to 1:3. Again, closely monitor for hemodynamic changes. If the patient remains stable, the IABP can be removed.*

*Weaning by reducing the augmentation or volume reduction weaning is similar in concept. In this method, the augmentation or volume of helium used to fill the balloon is gradually reduced. Most IABP allow the clinician to reduce the volume in 10% increments with a maximum augmentation volume of 100% and a minimum of 0%. While on full IABP support, the augmentation should be set to 100% and a frequency of 1:1. To gradually wean, reduce the augmentation in 20% increments. Assess the patient's hemodynamics for 15 to 30 minutes between augmentation reductions. Before removing the balloon catheter, confirm the patient's coagulation status. To prevent uncontrollable bleeding, no heparin should be circulating and the patient's INR/PT or ACT should be within normal ranges.*

17. What's the best trigger in normal circumstances?

*The best and most commonly used trigger is ECG. This can either be taken directly by the IABP or it can be slaved off the patient monitor.*

18. What should be checked if a “Rapid Gas Loss” alarm appears?

*Check for proper connection, leaks, and kinks in the gas line. The helium tank level should be checked after a rapid gas loss also.*

**Appendix D: Core Competencies for Intra-Aortic Balloon Pumps**

<b>Recognize optimal and suboptimal timing</b>
<b>Interpret and troubleshoot console alarms and abnormalities</b>
<b>Develop skills and knowledge enabling them to appropriately operate the IABP and identify the equipment required for the procedure.</b>
<b>Describe the purpose for IABP</b>
<b>List the indications and contraindications for use</b>



## **Appendix E: Updated IABP Objective-Based Clinical Competency Assessment**

### **Intra-aortic Balloon Pump (IABP) Quarterly Clinical Competency Exam**

**Student:** \_\_\_\_\_

**Level:** \_\_\_\_\_

**Clinical Instructor**

**Name:** \_\_\_\_\_

—

**Exam Date:** \_\_\_\_\_

**Clinical Outcomes: The student:**

- Demonstrates thorough knowledge of the indications and contraindications of use for IABP.
- Demonstrates a thorough understanding of optimal and suboptimal timing.
- Demonstrates the ability to interpret and troubleshoot console alarms.
- Can identify the equipment required for the procedure.

**Skill Criteria**

- 0- An act or failure to act in a potentially life-threatening situation
- 1- Unsatisfactory performance and knowledge, required complete assistance
- 2- Satisfactory performance, lacked complete knowledge, required high level of assistance
- 3- Satisfactory performance and knowledge, required little assistance
- 4- Satisfactory performance and knowledge, required no assistance

<b>IABP Insertion Assessment</b>	<b>Grade (1-4)</b>	<b>Instructor Comments and Feedback</b>
Able to explain four indications for IABP insertion		
Able to explain four contraindications for IABP insertion		
Can explain the physiological effects of IABP therapy on the cardiac cycle		
Can identify the most common insertion site		
Can identify where in the aorta the balloon and the tip of the balloon are positioned.		
Can list seven complications of IABP insertion		
<b>IABP Timing and Monitoring Assessment</b>	<b>Grade (1-4)</b>	<b>Instructor Comments and Feedback</b>
Can correctly verify the meaning of "augmentation"		
Can explain the physiological impact of: <ul style="list-style-type: none"> <li>• early inflation,</li> <li>• early deflation,</li> <li>• late inflation,</li> <li>• late deflation.</li> </ul>		
Can correctly verify three factors that affect diastolic augmentation		
Can explain how the IABP should be timed to inflate and deflate		
Can explain the physiological effect of inflation and deflation		
Can explain a complication of catheter immobility		
Can wean a patient from IABP		
Can identify when a pacer trigger should be used		

<b>IABP Basic Clinical Techniques Assessment</b>	<b>Grade (1-4)</b>	<b>Instructor Comments and Feedback</b>
Can correctly power up and set up the IABP for pumping		
Can correctly receive the catheter from sterile field		
Can autofill the IABP and then initiate the IABP		
Can correctly adjust the IABP augmentation, timing, & ratio		
Can adjust IABP to the appropriate settings during the simulated patient issues and scenarios		
<b>IABP Alarm Interpretations Assessment</b>	<b>Grade (1-4)</b>	<b>Instructor Comments and Feedback</b>
Took appropriate necessary actions and identified correct causes of the following alarms <ul style="list-style-type: none"> <li>• Check IABP catheter</li> </ul>		
Took appropriate necessary actions and identified correct causes of the following alarm: <ul style="list-style-type: none"> <li>• Autofill Failure-No Helium</li> </ul>		
Took appropriate necessary actions and identified correct causes of the following alarm: <ul style="list-style-type: none"> <li>• Low battery</li> </ul>		
Took appropriate necessary actions and identified correct causes of the following alarm: <ul style="list-style-type: none"> <li>• Autofill Failure-Blood Detected</li> </ul>		
Took appropriate necessary actions and identified correct causes of the following alarms: <ul style="list-style-type: none"> <li>• No Trigger</li> <li>• No Pressure Trigger</li> <li>• No Pressure Trigger – Zero Transducer</li> </ul>		

## Appendix F: Current MSOE MSP IABP Competency Exam

### Intra-Aortic Balloon Pump (IABP) Competency Exam

STUDENT \_\_\_\_\_

Exam Date \_\_\_\_\_

The student must demonstrate satisfactory clinical competency performing the following:

**P = PASS F = FAILURE**

☐

Demonstrate a thorough knowledge of the purpose of, the indications and contraindications for, and the overall mechanics of IABP therapy.

☐

Demonstrate a thorough understanding of the monitoring and timing options and the apparatuses involved in measuring these parameters.

☐

Demonstrate the ability to correctly perform the following IABP techniques:

- ✓ Power up the IABP console
- ✓ Set up the IABP console for pumping, using the help screen if necessary
- ✓ Receive the IABP catheter from the sterile field and connect it to the console
- ✓ Autofill the IABP catheter
- ✓ Initiate the IABP
- ✓ Adjust IABP augmentation
- ✓ Adjust IABP timing
- ✓ Adjust IABP ratio

☐

Demonstrate a thorough understanding of properly timing and triggering the IABP according to the following cardiac rhythms:

- ✓ Normal sinus
- ✓ Atrial fibrillation
- ✓ 100% ventricular pacing
- ✓ Asystole

☐

Demonstrate a thorough understanding of correcting the following IABP alarming conditions:

- ✓ Augmentation below set limit
- ✓ Loss of trigger
- ✓ Rapid gas loss
- ✓ Check IABP catheter
- ✓ Leak in IABP circuit

COMMENTS:

Clinical Examiner's Signature

Date

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**Cardiovascular Studies****Thesis Approval Form****Master of Science in Perfusion - MSP****Milwaukee School of Engineering**

This thesis, entitled “The Development of a Comprehensive Intra-Aortic Balloon Pump (IABP) Study Guide for Perfusion Students,” submitted by the student Ryan Schmidt, has been approved by the following committee:

Faculty Advisor: \_\_\_\_\_ Date: \_\_\_\_\_

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Faculty Member: \_\_\_\_\_ Date: \_\_\_\_\_

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