Clinical Practice Guidelines for the Anesthetic Management of Patients with Pulmonary Hypertension

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Abstract

Problem: Pulmonary Hypertension (PH) is a severe, progressive, disease with limited treatment options and poor prognosis. The risk of morbidity and mortality increases significantly when patients with PH must undergo surgery. There is a reported 42% increase in morbidity of patients with PH and the rate of perioperative mortality varies between 1-18% for patients undergoing non-cardiac, non-obstetric surgery. A small, academic, secondary care hospital within Maryland has reported an increase in adverse events among patients with PH, including unexpected or prolonged ICU admissions, and respiratory failure. The hospital has identified a need to standardize the care of anesthesia providers in the areas of perioperative management of PH to maximize outcomes and reduce morbidity and mortality.

Objective: The purpose of this doctor of nursing practice (DNP) project was to develop and evaluate a clinical practice guideline (CPG) for the intraoperative anesthetic management of PH patients presenting for non-cardiac, non-obstetric surgery. The anticipated outcome of implementation was a reduction in perioperative adverse events such as respiratory failure, heart failure, hemodynamic collapse, abortion of surgical procedure, and unexpected ICU admission.

Methods: The project occurred in a three stage format. In the first stage, the most current literature on the intraoperative management of patients with PH was evaluated and a guideline developed using Brower's Agree II tool. The tool consists of 23 items within 6 quality domains; each domain focuses on a specific feature of a CPG. A team of appraisers critically analyzed and scored the guideline using the Agree II tool. In the second stage, the guideline was evaluated by anesthesia providers using Brower's practitioner feedback questionnaire (PFQ). This tool seeks

to evaluate guideline clarity, effectiveness of guideline recommendations, and guideline completeness. Data was collected from the questionnaire to determine the suitability of the guideline for practice.

Results: The scores of the Agree II tool were aggregated into an overall domain score. The highest scores came from the domains: scope and purpose (86%), stakeholder involvement (92%), clarity and presentation (85%), and editorial independence (100%). The lowest scores where in the areas of: rigour of development (80%), and applicability (60%). From the PFQ data agreement or strong agreement was indicated 88% of the time when practitioners were questioned about the need for a guideline, or agreement with the guidelines content. However, the results of the PFQ echoed weaknesses brought to light by the Agree II appraisal. Only 72% of providers agreed that the draft recommendations would make an obvious effect on patient outcomes.

Implications: Based on the Agree II and PFQ results, guideline developers decided to incorporate facilitators, barriers, and implications of guideline use into the CPG. The guideline team strongly believes that it is prudent for providers to use the best evidence available to treat patients, and while PH research is limited, the sources that are available should be consulted as a guide for better outcomes. After final review, guideline recommendations were submitted to the anesthesia department as a source of quality improvement. These guidelines are not to be considered generalizable knowledge.

Pulmonary hypertension (PH) is a pathological disorder of the cardiovascular and respiratory system that requires careful, multidisciplinary treatment. The European Society of Cardiology broadly defines PH as an increase in mean pulmonary arterial pressure (PAP) ≥25 mmHg at rest, as determined by right heart catheterization (Galiè, et al. 2016). Within the United States the overall death rates attributed to PH have increased in the last decade, with a significant increase noted from 2006 to 2010 (George, et al. 2014). Compared to the rest of the nation, the state of Maryland experiences over 1.5 times more deaths related to PH than other parts of the country (George, et al. 2014). George et al. (2014) found that the increase in deaths related to PH are positively correlated with a diagnosis of aortic stenosis, hypertension, coronary artery disease, autoimmune diseases, diabetes, renal disease, and/or chronic liver disease. Death rates rose more significantly for the elderly, women, and African American populations (George, et al. 2014). The risk of an adverse outcome increases significantly when patients with PH must undergo surgery.

Perioperative management for patients diagnosed with PH present unique challenges to the anesthesia care provider. There is a reported 42% increase in perioperative morbidity of patients with PH (Kaw, et al. 2011). These patients are more likely to develop congestive heart failure, hemodynamic instability, sepsis, respiratory failure, require longer stays in the intensive care unit, and have more frequent readmissions to the hospital (Kaw, et al. 2011). The rate of perioperative mortality varies between 1-18% for PH patients undergoing non-cardiac, non-obstetric surgery (Pilkington, Taboada, & Martinez, 2015). Numerous studies have confirmed that there is a direct correlation between higher pulmonary artery systolic pressures, and poor postoperative outcomes (Lai, et al. 2007). Given these dangers it is incumbent upon anesthesia

care providers to maximize patient outcomes and provide a smooth operative course for patients with PH.

A small, academic, secondary care hospital within Maryland had reported an increase in adverse events among patients with PH, including unexpected or prolonged ICU admissions, respiratory and cardiac failure, and early termination of surgical procedures, cardiac arrest, and death. The hospital has identified a need to standardize the care of anesthesia providers in the area of perioperative management of PH to maximize intraoperative care and reduce morbidity and mortality. One intervention to address this problem is the implementation of a clinical practice guideline (CPG) specifically for the anesthetic management of PH.

The purpose of this scholarly project was to develop an evidenced based clinical practice guideline for the anesthetic management of adult patients with pulmonary hypertension undergoing non-cardiac, non-obstetric surgery. The anticipated outcomes associated with the guidelines are a reduction in perioperative adverse events such as sepsis, respiratory failure, heart failure, renal failure, myocardial infarction, hemodynamic collapse, abortion of surgical procedure, and unexpected ICU admission. The guideline will serve as a blueprint to optimize outcomes for patients with pulmonary hypertension at this organization.

Theoretical Framework

The IOWA model provided the theoretical framework for this project. The Iowa Model encompasses seven steps: 1.) Select a topic, 2.) Form a team, 3.) Retrieve the Evidence, 4.) Grade the evidence, 5.) Develop an EBP standard, 6.) Implement EBP, and 7.) Evaluate the change (Doody &Doody, 2011). The Iowa model is easily applied to the development of CPGs

and provided the organizing structure for this project. The first step of the model broadly identifies the topic of the problem (White & Spruce, 2015), for this organization the problem is an increase in perioperative adverse events for patients diagnosed with PH. The second step forms a multidisciplinary team of stakeholders involved in the change (Doody& Doody, 2011). The multidisciplinary team included anesthesiologists, nurse anesthetists, and three doctoral student registered nurses. The third step identifies sources of evidence via literature review, and the fourth step grades the strength of the evidence. A literature review table is included in this proposal (see appendix A). During the fifth and sixth steps recommendations are set for practice, the EBP is implemented (Doody & Doody, 2011). For this project the multidisciplinary team met and discussed evidence, revised guidelines, determined barriers to implementation; gained buy in of stakeholders, and planned how the changes in practice would occur. The final step in the IOWA model is an evaluation of the practice change. Evaluation allows team members to determine what barriers still exist and if the changes are making the desired effect (Doody& Doody, 2011). This step was accounted for in the final version of the clinical practice guideline and will be accomplished if the organization chooses to implement the guideline and would utilize chart reviews to analyze length of stay, adverse events, morbidity, and mortality of patients with PH.

Evidence Review

The evidence to support the development of a clinical practice guideline for the intraoperative anesthetic management of patients with PH undergoing non-cardiac, non-obstetric surgery is the focus of this literature review. The review will begin with a description of the intraoperative anesthetic and hemodynamic goals for the management of PH. This is will be

followed by an analysis of the types of anesthetic approaches best served in the PH patient population. A review of intraoperative monitoring tools and pharmacologic strategies will be outlined. Finally, management strategies of acute decompensation in the operative suite will be discussed.

Two literature reviews act as sources of evidence for the perioperative management of patients with PH. Pilkington et al. (2014) analyzed 44 research studies from 2003-2014 on the anesthetic management and principles behind prevention of a PH crisis in the operative suite. Minai et al. (2013) analyzed 73 studies from 1966-2011 and discussed surgical factors that can worsen PH. Both reviewers caution against factors that can increase pulmonary vascular resistance (PVR) including: positive pressure ventilation with high tidal volumes, unnecessary positive end expiratory pressure (PEEP), hypercarbia, hypoxia, acidosis, pain, excessive airway instrumentation, fluid overload, nitrous oxide, and arrhythmias. The reviewers recommend management principles to avoid a decrease in systemic vascular resistance (SVR) including: using etomidate or ketamine as an induction agents, avoiding excessive narcotics or benzodiazepines, and the prompt use of vasopressors to correct hypotension. Anesthetic goals should focus on preventing an increase in PVR, avoiding hypoxemia, and maintaining SVR. Overall, the reviewers stress the importance of maintaining stable intraoperative hemodynamics.

Several limitations were identified in the two reviews. Each analyzed only a small number of randomized control trials. Most of the studies were based on retrospective design; other studies were limited by selection bias and small sample sizes. PH was often only diagnosed based on echocardiography rather than right heart catheterization, and all studies showed a possible attrition bias due to lack of adequate follow up.

Despite the limitations of the reviews, general, neuraxial, and regional anesthesia were found to be equivalent in terms of patient outcomes and can be safely employed in the PH population (Minai et al. 2013; Pilkington et al. 2014). This finding is consistent with a study conducted by Lai et al. (2007), who performed a control trial without randomization to evaluate perioperative adverse outcomes for 62 patients from 1999-2004 undergoing non-cardiac surgery. Researchers found no differences in outcomes of patients undergoing general, neuraxial, or regional anesthesia techniques.

In contrast to the above findings, some researchers have reported differences in outcomes dependent upon the type of anesthesia used. Price et al. (2010) conducted a retrospective cohort study in France which included 28 patients with known PH who underwent general, neuraxial, or regional anesthesia for non-cardiac, non-obstetric surgery. Those who underwent general anesthesia showed less hemodynamic impairment then those undergoing a regional approach. However, more perioperative complications occurred in procedures performed under general anesthesia when compared to regional anesthesia ($p=0.12$). Price, et al. (2010) attributed the higher complication rate from general anesthesia to the type of surgery that was performed. In the study, PH patients undergoing major surgery or emergent surgery were only administered general anesthesia. These procedures could not be case controlled with a similar surgery using regional or neuraxial anesthesia. The investigators proposed that the perioperative complications were likely due to the risk associated with the procedure, not the anesthetic.

Bennett, et al. 2014 also found a difference in outcomes in regard to the type of anesthetic administered. In a small, retrospective controlled trial Bennett, et al. (2014) found a greater incidence of mortality in patients undergoing monitored anesthesia care (MAC) cases then those

undergoing regional or general anesthesia. This difference may be in part due to the small sample size, and a lack of adequate statistical testing. Without a power analysis, this study is more at risk for a type II error. Moreover, this study considered patients with Eisenmenger syndrome in addition to a diagnosis of PH, which may explain the difference in results.

The impact of invasive monitoring tools on perioperative outcomes has also been studied for patients with PH. Both Minai, et al. 2013 and Pilkington, et al. 2014 advocate for the use of invasive monitoring tools in patients with severe PH. These tools include; an arterial line, central venous pressure monitoring, and/or a Swan Ganz catheter. Minai, et al. 2013 supports the use of a Swan Ganz catheter to guide pulmonary vasodilator therapy, intraoperative vasopressor use, and fluid replacement. In contrast, Pilkington, et al. 2014 found that regardless of the type of invasive monitoring tool placed patient outcomes were not positively affected. Despite this finding, Pilkington, et al. 2014 still recommends frequent arterial blood gas analysis throughout the operative course. Additionally, both reviewers support the use of trans-esophageal echocardiography after intubation for patients with severe PH, undergoing major or prolonged surgery (Pilkington, et al. 2014 and Minai, et al. 2013).

The anesthesia provider must consider the unique pharmacologic implications of PH. The potential for respiratory compromise, and subsequent increased PVR, should be considered in selecting intraoperative medications. During induction, PH patients are at an increased risk for prolonged effects of sedatives, opioids, and inhaled anesthetics which may lead to right sided heart failure, and hemodynamic collapse (Bennett, et al. 2013, Minai, et al. 2013, and Pilkington, et al. 2014). The anesthesia provider should administer benzodiazepines and opioids judiciously during induction of anesthesia. Minai, et al. 2013 found that induction agents Etomidate and

Ketamine preserved SVR with little effect on PVR. Bennett, et al. 2013 also found Etomidate produced the least impact on cardiovascular stability on induction, and cited Propofol as the most frequent cause of hypotension. Reviewers agree that medication management must focus on preserving SVR, preventing an increase in PVR and maintaining normotension during the course of anesthesia.

The maintenance phase of anesthesia presents its own challenges to hemodynamic stability. Pilkington, et al. 2014 and Minai, et al. 2013 suggest that all inhalation agents used for the maintenance of anesthesia decrease right ventricular contractility. Pilkington, et al. 2014 further suggests that Desflurane and Isoflurane will increase PVR, while Sevoflurane will not modify PVR and therefore maybe a better choice of inhalational gas. Both reviewers agree that Nitrous Oxide causes the greatest increase in PVR and both recommend that this drug should be avoided in the PH population (Minai, et al. 2013, and Pilkington, et al. 2014). Regardless of anesthetic choice, both reviewers stress the importance of maintaining stable intraoperative hemodynamics.

In the scenario of an acute compromise in intraoperative hemodynamics measures should be taken to reduce PVR. Minai, et al. 2013 suggests the use of inhaled nitric oxide, prostacyclin, or parenteral sildenafil to acutely reduce PVR. Minai, et al. 2013 further suggests that if pharmacologic management is not adequate to maintain hemodynamic stability then a surgically implanted device, such as an intra-aortic balloon pump, or left ventricular assist device should be considered. Pilkington, et al. 2014 echoes these recommendations and suggest that inhaled agents combined with intravenous inotropes and inodilators such as milirione, may be more beneficial than either class of medication used alone.

Viewed collectively, these studies supported the development of a clinical practice guideline for the intraoperative management of patients with PH undergoing non-cardiac, non-obstetric surgery. Intraoperative guidelines focus on anesthetic strategies aimed at maintaining SVR, correcting hemodynamic alterations, and preventing an acute increase in PVR. Regardless of the anesthetic approach and invasive monitoring tools used during surgery, anesthesia providers must respect the complex management implications of a PH diagnosis.

Methods

Design and Setting

The design for this project is the development and evaluation of a clinical practice guideline (CPG). The project will take place within a perioperative setting in a small academic, secondary care hospital in Baltimore, Maryland. For a complete timeline of procedures see appendix B.

Sample and Procedures

The project occurred in three stages, each with a different sample. In the first stage, the sample consisted of a team of stakeholders, including one anesthesiologist (MDA), and three doctoral students, who served as project leaders. The team of stakeholders arranged weekly, hour long meetings, over four weeks to review a preliminary draft of the CPG and used the AGREE II tool to assess the quality of the guidelines produced. A student project leader directed each meeting, and another student functioned as a recorder for the meetings to ensure that key points of the meeting were upheld. During the first meeting, a timeline was established, the AGREE II tool introduced, and the stakeholders were given a draft CPG to review before the

next week. Each team member completed an electronic version of the AGREE II tool and during the subsequent meetings revisions to the CPG were discussed and made based on overall scores from the AGREE II. After a consensus was reached on the adequacy of the guideline, the team planned a presentation of the guideline and set a date to begin stage two of the project.

In the second stage, after the stakeholders had drafted and revised the CPG, the draft was presented at a staff meeting to the second sample (n=19) consisting of Certified Registered Nurse Anesthetists (CRNA's), Student Registered Nurse Anesthetists (SRNA's) and MDA's working on the perioperative unit. The presentation occurred over the course of an hour, with time allotted for questions and feedback from providers. At the end of the presentation data was collected using a modification of Brower's et al. 2004 Practitioner Feedback Questionnaire (PFQ)(See Appendix D). Paper copies of the survey were disseminated and directions on how to use the PFQ were explained. A secure collection box was placed by the exit for completed surveys to be returned. The data was then collected and analyzed by the project leaders, and further revisions were made to the CPG based on provider feedback before moving into stage three of the project.

In the third stage, the sample will consist of the Chief Anesthesiologist (n=1), a meeting will be set with the Chief Anesthesiologist to discuss key recommendations of the CPG and staff response based on feedback from the PFQ. The chief will be given copies of the CPG, literature review, and appraisal tools to review. The CPG team will give the chief a synopsis of the project, its findings, and staff response to the presentation. The Chief Anesthesiologist will be given an opportunity to ask questions, make suggestions, and determine whether or not to approve the CPG within the facility. After

the meeting a copy of the CPG (Appendix C) and its contents were uploaded into the anesthesia lounge computers for staff reference.

Data collection

The AGREE II tool is a modification of the AGREE instrument which has been successfully used and endorsed by health care organizations (Brouwers, et al. 2010). The AGREE tool was updated to the AGREE II tool in 2013 to maintain reliability (Cronbach alpha score 0.64-0.88) (Brouwers, et al. 2010). Additionally, the updated tools validity was deemed adequate when assessed for inter-rater reliability. (Brouwers, et al. 2010). The AGREE II tool consists of 23 items within 6 quality domains; each domain focuses on a specific feature of a clinical practice guideline (Brouwers, et al. 2010). The tool measures CPG scope and purpose, stakeholder involvement, rigor of development, clarity of presentation, applicability, and editorial independence (Brouwers, et al. 2010). Each item in the AGREE II tool is rated on a 7 point Likert scale; items are rated from 1 (*strongly disagree*) to 7 (*strongly agree*), all 23 items in the tool will be assessed for this project. The Agree II tool can be completed online or as a hard copy, and should take about thirty minutes to complete. The online tool was used to assess the draft of the CPG developed during stage one of implementation.

The second tool, the Practitioner Feedback Questionnaire (PFQ), was adapted from Brower's 2004, *Clinicians' assessments of practice guidelines in oncology*. It consists of 23 questions that were found to be statistically significant ($p<.0001$) regarding guideline clarity, effectiveness of guideline recommendations, and guideline completeness (Brouwers, et al. 2004). Each item in the modified PFQ is rated on a 5 point Likert scale; items are rated from 1 (*strongly disagree*) to 5 (*strongly agree*), and the survey takes roughly ten minutes to complete. All 23

items in the PFQ were assessed for this project. Demographic data of respondents was also collected with the questionnaire. This information was used to calculate the social characteristics of the sample. Finally, feedback was solicited from administration, on the feasibility and thoroughness of the CPG. All data was collected over the course of eight weeks

Data Analysis

Data derived from the AGREE II tool was considered interval level for the purpose of this project and was analyzed with statistical testing. A quality score was calculated for each of the six AGREE II domains (Brouwers, et al. 2010). Domain scores were calculated by summing up all the scores of the individual items in a domain for each appraiser, and calculating a total score for the domain (Brouwers, et al. 2010). The six domain scores are independent and should not be aggregated into a single quality score (Brouwers, et al. 2010). A scaled total was then calculated as a percentage of the maximum possible score for that domain (Brouwers, et al. 2010). Domain scores were used to compare guidelines and to inform appraisers as to whether a guideline should be recommended for use. However, the minimum domain scores across domains to differentiate between high quality and poor quality guidelines have not been established and are at the discretion of the stakeholders (Brouwers, et al. 2010). Scores for each domain were reviewed by the CPG team and domains with low scores were evaluated for areas of improvement.

The data from the PFQ was also considered interval level data and described with statistical analysis. For the demographics collected, the number of MDA's, CRNA's, SRNA's, participant's gender, ethnicity, and year's practicing anesthesia were tallied, and the percentage of each of these characteristic described. The twenty three questions in the PFQ were

individually scored for the mean and the percentage of participants who rated the item as a 4 or a 5 indicating that they agree or strongly agree with the statement.

Protection of human subjects

The proposal was sent for review by the University of Maryland Baltimore (UMB) and the local hospital's IRB for a Nonhuman Subjects Research determination (See Appendix E). Participants were voluntary and remained anonymous; no identifiers were collected on those who completed the tools. The PFQ was completed by hand and submitted in a secure envelope immediately following guideline presentation. As an additional safety measure, only members of the team were able to access data. Once collected, the data was transcribed into a password protected computer and the paper tools destroyed.

Results

The highest available score using the AGREE II tool is a seven, indicating a strong agreement. The lowest possible score is a one, indicating strong disagreement (Brouwers, et al. 2010). The four CPG team appraisers independently rated each of the 23 questions from 1-7 (see table one). Once every team member had completed their appraisal, the team then reviewed each of the scores anonymously, using the AGREE II website to blind reviewers to each other's scores. The overall domain score is calculated by finding the maximum possible score for the domain (max score of 7 x 3 questions in domain one x 4 appraisers) and subtracting the minimum possible score of the domain (Minimum score 1 x 3 questions in domain one x 4 appraisers)

84-12=72

This number is then used as a dividend and the actual obtained score is subtracted from the minimum possible score as the divisor. The domain score is reported as a scaled percentage and the entire equation is multiplied by 100 to give the overall score.

(74-12=62)/72 x 100= 86% Domain one score

The quality score was calculated for each of the six domains and the results are displayed as a scaled percentage (see table two).

Scope and Purpose

The domain Scope and Purpose consists of three questions which evaluate: 1) The overarching goal of the guideline, 2) The health questions the guideline addresses and 3) The target group for which the guideline is intended. The mean score for this domain was 6.16 (CI 3.29-9.04). The four appraisers rated each item from 1 to 7 as shown in table one. Two of the appraisers gave each of the questions in this section a score of seven, while the other two appraisers were more critical. Overall, the domain scored 86% indicating that the overall objectives of the guideline were well described.

Stake Holder Involvement

This domain includes three questions which evaluate; 1) If the guideline has clearly specified its target users, 2) If the views of the target population have been sought, and 3) If all pertinent groups have been consulted in the making of the guideline. The score for this domain was high with a mean of 6.5 (CI 4.31-8.69). Almost every appraiser rated the three questions in this section a 7 out of 7. The sixth question, which assesses the target users of the guideline, was

rated the most highly, with every appraiser indicating a strong agreement. Overall, this domain scored a 92%. The appraisers seem to agree that the CPG adequately describes the target population and intended users, and has sufficiently addressed patient preferences.

Rigour of Development

This domain consists of seven questions which analyze; 1) The thoroughness of guideline development, 2) The procedure for guideline data collection & recommendations, and 3) Outline the procedure for updates to the guideline. The mean score for this domain was 5.78 (CI 4.27-7.28). A wide range of scores were assigned to this domain, the lowest score for this section was given to question fourteen which asks about a procedure for updating the guideline. As a whole this domain scored 80% one of the lowest domain scores.

Clarity and Presentation

This domain consists of three questions which evaluates the format and overall presentation of the guideline. The mean score for the domain was 6.08 (CI 3.23-8.93). The majority of the questions in the domain were rated as a seven. The lowest score in this domain was given to the ability to identify key recommendations. An overall score of 85% was given to this domain.

Applicability

This domain covers four questions relative to the resources, barriers, and facilitators of guideline implementation. There was a fair amount of disharmony among appraisers in this section which was reflected in the overall score of the domain. The mean for this domain was 4.63 (CI 2.06-7.19). One appraiser scored all of the questions as a 1 while other appraisers gave scores between 3 and 7. The domain score for this section was 60%.

Editorial Independence

This domain consists of two questions to evaluate competing interests of the guideline developers. This was the highest score of the domains, with 100% agreement between appraisers. The mean for this domain was 7 indicating that there is no conflict of interest for the guideline developers.

Overall Assessment

This domain has appraisers choose a total score for the guideline then state if they believe the guideline should be recommended for practice. The mean for this domain was 5.25 (CI 1.37-9.31) with all four appraisers stating the guidelines should be used for practice, although some appraisers indicated the need for guideline modifications before implementation. The overall score for this domain was 71%

Practitioner Feedback Data

The proposed sample size for stage two of guideline development was (n=30). This number was determined by guideline developers to be an adequate reflection of anesthesia providers within this hospital setting. However, actual response rates for the PFQ survey was less than this target number. A total of 19 surveys were collected immediately following guideline presentation in stage two of project development. Additional surveys were left with copies of the guideline and presentation in the anesthesia break room, for one week in the hopes of collecting additional data. However, no additional data was received. Therefore the new sample size was made n=19. Each PFQ survey included questions about baseline demographic statuses, such as gender, ethnicity, years worked at institution, and the provider's role within the

anesthesia group. Table three (below) lists how practitioners were grouped according to different categories.

Of the 19 practitioners surveyed there were a total of 5 SRNAs, 5 MDAs, and 9 CRNAs. A fairly even distribution of male (47%) and female (52%) providers completed the survey. The majority of providers (37%) had less than 5 years' experience practicing anesthesia. A large majority (63%) of respondents described themselves as Caucasian, (16%) described themselves as African American and (20%) of the sample chose to identify themselves as other, or to leave the response blank. One of the practitioners only provided their demographic data and failed to complete the actual survey, because of this the total sample size used in the calculations of PFQ data was reduced (n=18). Members of the guideline development team were included in the total number of respondents (n=4), 21% of the sample was involved in the guideline development.

Practitioner feedback was sought for opinions on PH guidelines through use of the PFQ. The guideline attempts to assess the respondent's perception of the guidelines while also assessing the guidelines ability to meet a clinical need. Table four (below) lists responses to items asked in the PFQ. The table reflects the number of providers who either agree or strongly agree with each of the questions. The overall mean score for each question is listed.

From the data collected, agreement or strong agreement was indicated 88% of the times when practitioners were questioned about the rationale for guideline development, the need for a guideline, or agreement with guideline content. An equally positive response was found when providers were asked if guideline use could improve clinical practice. The approval rates for the methodology, literature search, and unaltered guideline draft received a 78% approval rating.

Written comments occurred in 27% of respondents, and most involved encouraging comments towards the CPG development.

Discussion

The results of this project suggest that implementation of a CPG following best practice guidelines for the perioperative management of PH may reduce post-surgical unexpected ICU admissions, respiratory failure, and prolonged intubations requiring extended ventilator support at this facility (Kaw et al., 2010; Minai et al., 2013; Pilkington et al. 2014; Price et al., 2010). The AGREE II appraisal results show that the guideline carries a moderate level of quality, which varies across the six domains. Four of the six domains carried high quality scores between 85-100%. The guideline developers ensured that the scope and purpose of the guideline was carefully and specifically described, that the target users of the guideline where addressed, that recommendations where made specific and unambiguous, and that any conflicts of interests among developers were explicitly recorded. The domains rigour of development, and applicability, rated as lower quality, due to the lack of available research. The scores for rigour of development are based on the ability to synthesize evidence, formulate recommendations, and have a plan for updating guidelines. Unfortunately, the evidence pertaining to PH patients undergoing surgical procedures is limited, and often outdated. The majority of the studies used for the guideline were rated between a 3A-7B on the Newhouse and Melnyk & Fineout-Overholt rating scale. Most of the studies are limited by ethical constraints, and carry a high risk of attrition. Therefore, recommendations have been made using an accumulation of data from 1970 onwards and it is of utmost importance that these guidelines are frequently updated based on research as new studies emerge.

The lowest scoring domain was that of CPG applicability. This domain discusses facilitators and barriers to guideline implementation, and implications of guideline use. The AGREE II assessment rating of 60% in this domain showed that guideline developers needed to formulate a better plan to ensure guideline success. Areas of guideline weakness included providing tools and recommendations for implementation, and addressing the implications of applying the recommendations. After the guideline was made and assessed using the AGREE II tool group members were able to address these flaws.

The development team analyzed barriers to CPG implementation; planned ways to gain buy in of stakeholders, and planned how the changes in practice will occur. The Iowa models implementation guide suggests four key principles for successful implementation. These include: 1.) Creating staff awareness and interest, 2.) Building knowledge and commitment, 3.) Promoting action and adoption, and 4.) Pursuing integration and sustained use (White and Spruce, 2015). In order to create staff awareness, the advantage of the change and its anticipated impact (reduced ICU admissions, and reduction in perioperative adverse events such as: sepsis, respiratory failure, heart failure, renal failure, myocardial infarction, hemodynamic collapse, abortion of surgical procedure) should be highlighted to staff members. Unit in-services, newsletters and announcements should be made. Clinicians should be prepared with written material, educated on the new practice benefits, and verbal communication should promote adoption of the practice change (White and Spruce, 2015). Knowledge can be built by utilization of pocket references, encouraging clinician input, and assigning a change champion (White and Spruce, 2015). Change champions are clinicians who have a positive relationship with staff members and act a liaison to encourage a practice change (Tilter, 2008). To promote action and

adoption a multidisciplinary approach should be emphasized and a workflow algorithm of practice changes should be available for staff reference (White and Spruce, 2015). Finally, the sustained integration of change can be promoted by sharing feedback and revisions with staff and reporting performance audits. Individuals should receive feedback on progress and celebration of performance should be encouraged (White and Spruce, 2015). Evaluation should be ongoing, and allows team members to determine what barriers to change exist and if the changes are making the desired effect (Doody& Doody, 2011). Baseline data on outcomes prior to CPG implementation could be collected so that pre and post adoption data can be compared for intervention effectiveness. Pre implementation data should be collected for the six months prior to CPG adoption. Upon implementation of the CPG, data should be continuously collected to compare the significance of EBP on adverse events, morbidity, and mortality of patients with PH. A brief description of these implementation strategies to address facilitators and barriers to CPG application was added to the guideline (see Appendix C)

It should be noted that the AGREE II tool requires subjective judgment when selecting domain scores. The domain scores are used as a guide for determining if the recommendations contained in a CPG should be implemented. However, there is not currently a minimum domain score which is required for a guideline to be put into practice. It should also be noted that the current literature on anesthetic outcomes for PH patients is scarce, with limited practice guidelines for the management of this tenuous population. In the validity and reliability of guidelines that do exist are undetermined. With this information, guideline developers determined that the overall assessment score of the CPG (71%) was adequate to support its use in

practice. Reviewers agreed that the CPG should be implemented, but with modifications that accounted for frequent research based updates and translation into practice.

An essential component of guideline appraisal is feedback from persons who will be directly involved in guideline recommendations. The PFQ seeks provider's opinions on draft guidelines. When the draft of the guideline was presented to practitioners in Stage II of project development, it was well received with 88% of respondents stating a need for a guideline on the topic. Several practitioners admitted a discomfort with the complexity surrounding PH patients and most of the staff was interested in having a reference to help guide their care of this difficult population. However, some providers felt strongly that a guideline would offer "cookbook anesthesia" and could not be applied to each PH patient subset. Interestingly, some providers expressed a desire for a more stringent guideline, with absolute values for patients who should or should not be cared for within the community hospital setting. This guideline sought to be a middle ground between the two ideals, leaving room for patient specific interpretations and provider judgment. It was therefore encouraging to have an 82% provider approval rating of the guideline on the PFQ survey. If this approval rating will translate into full adoption of the CPG is still unknown.

The results of the PFQ echoed the CPG weaknesses brought to light by the Agree II appraisal. Practitioners were skeptical about the limited sources of literature, and the weaknesses of the research studies used to make the guidelines. Several providers expressed doubt that the recommendations would be beneficial. Only 72% of providers agreed that the draft recommendations would make an obvious effect on patient outcomes. This mirrors the 77% approval of the literature review. Guideline developers were transparent in the level and grade of

the evidence used to draft the guideline, as such this score was an expected to be rated low. The guideline team strongly believes that it is prudent for providers to use the best evidence they have to treat patients, and while PH research is limited, the sources that are available should be consulted as a guide for better outcomes. There seems to be some agreement with this sentiment among anesthesia staff as 83% of providers stated that they would be comfortable with their patients receiving the care recommended by the guideline.

To date some of the recommendations have been implemented within the facility. In regards to intraoperative management, one of the drugs that can be utilized during PH crises, Milirione, has been moved into the anesthesia supply room, where it can be readily available to providers. There has been no formal measurement of practitioners following the intraoperative recommendations outlined in the guideline; however, 88% of providers stated that they would use the guideline in their own practice. Several of the tools and references provided in the guideline for the intraoperative anesthetic management of PH patients are now being used by the site as a reference, and for teaching of incoming SRNA's. This is especially encouraging, as it echoes the high approval rating of the guideline. Ideally, the guideline should be reassessed over time to determine the extent to which recommendations have been accepted for use.

Implications for clinical practice

Anesthesia providers are faced with the task of monitoring and maintaining the hemodynamics of chronically ill PH patients, while also optimizing the conditions for surgery. A safe, evidence based approach is a way to help providers manage these fragile patients. With the prevalence of PH increasing and more patients presenting for surgery, evidence based guidelines should be implemented to ensure better outcomes. Thorough preoperative screening and vigilant

intraoperative and postoperative management can decrease the adverse outcomes associated with PH.

Although, a CPG is a good starting point for managing care, this in itself may not be enough to prevent detrimental outcomes in patients with severe PH. More research is needed on the best anesthetic approach to improve PH patient survival rates. Piloting a study, to look at the effects of modern anesthetic medications and surgical stress could reveal a way to better manage patient outcomes. An expansion of resources within this organization to obtain the recommended medications and equipment necessary to treat PH crises, although costly, would be lifesaving. A referral program should be started by creating a partnership between one of the nearby large academic centers, where specialists could be consulted to aid in the screening and management of the most severe PH patients.

Conclusion

Overall, the guideline was given a 71% approval rating using the AGREE II tool and an 82% approval rating via practitioner feedback. To improve PH patient survival outcomes, a well-developed CPG is needed. This project demonstrated that the anesthetic management of PH patients within this community hospital could be improved by implementation of a CPG. However, implementation of a guideline will not be sufficient for patients with severe PH. Anesthesia providers within this organization can take steps to improve outcomes by forming a multidisciplinary team of; nurses, pulmonologists, cardiologists, pharmacists, surgeons, and anesthetists to improve perioperative PH management. Access to equipment and medications for the treatment of acute PH crises and partnerships between the community hospital and larger

academic centers are needed to expand resources to life saving treatment modalities for patients suffering from PH.

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Table one: *Quality score for domain one: Scope and Purpose*

Item	Appraiser 2	Appraiser 1	Appraiser 4	Appraiser 3	**Item total score**
1	5	7	7	6	**25**
2	6	7	7	2	**22**
3	6	7	7	7	**27**
Appraisers summative domain score	17	21	21	15	**74**

Table two: AGREE II Domain Scores

	Scope and Purpose	Stakeholder involvement	Rigor of development	Clarity and Presentation	Applicability	Editorial Independence	Overall assessment
Mean (SD) 95%CI	6.16 (1.46) 3.29-9.04	6.5 (1.45) 4.31-8.6	5.78 (1.34) 4.27-7.28	6.08 (1.49) 3.23-8.93	4.63 (1.67) 2.06-7.19	7 (0) 7	5.25 (1.56) 1.37-9.31
Guideline Scores %	86	92	80	85	60	100	71 Recommended with modifications

Table three: Frequency Distribution of Participant Demographics from Practitioner Feedback Survey

Variables	n	%
Age		
20-30	4	21.1
30-40	8	42.1
40-50	3	15.8
50-60	3	15.8
60-70	1	5.3
Gender		
Male	9	47.4
Female	10	52.6
Participant's Role		
CRNA	9	47.4
SRNA	5	26.3
MDA	5	26.3
Ethnicity		
AA	3	16.7
Caucasian	12	66.7
Other	3	16.7
Missing	1	5.6
Years Practicing in Role		
<5	7	38.9
5-10	5	27.8
10-15	2	11.1
15-20	0	0
20-25	2	11.1
>25	2	13.3
Missing	1	5.6

Years Practicing at Facility		
<5	9	50.0
5-10	7	38.9
10-15	1	5.6
15-20	0	0
20-25	0	0
>25	1	5.6
Missing	1	5.6

Table four: Quality Rating of CPG from PFQ Data

Practitioner Feedback Questionnaire - Summary of Agreement or Strong Agreement on Likert Scale

Survey Item	Percentage of Agreement (%)	Mean (SD)
2.The rationale for developing a guideline is clear.	88	4.5 +/-1.06
3.There is a need for a guideline on this topic.	88	4.6+/-1.04
4.The literature search is relevant and complete (e.g., no key evidence was missed nor any included that should not have been) in this draft guideline	77	4.1+/-1.09
5. I agree with the methodology used to summarize the evidence included in this draft guideline.	77	4.4+/-1.15
6.The results of the evidence described in this draft guideline are interpreted according to my understanding of the evidence.	77	4.3+/-1.13
7.The draft recommendations in this report are clear.	72	3.9+/-1.09
8. I agree with the draft recommendations as stated.	88	4.3+/-1.05
9.The draft recommendations are suitable for the patients for whom they are intended.	83	4.3+/-1.07
11.When applied, the draft recommendations will produce more benefits for patients than harms.	88	4.3+/-1.05
12.The draft guideline presents options that will be acceptable to patients.	77	3.8+/-0.99
16. The draft guideline recommendations are likely to be supported by a majority of my colleagues.	83	4.1+/-1.06
17. If I follow the draft guideline recommendations, the expected effects on patient outcomes will be obvious.	72	3.9+/-1.10
18. The draft guideline recommendations reflect a more effective approach for improving patient outcomes than is current usual practice.	83	4.3+/-1.11
19.When applied, the draft guideline recommendations will	88	4.3+/-1.05

result in better use of resources than current usual practice.		
20. I would feel comfortable if my patients received the care recommended in the draft guideline.	83	4.2+/-1.05
21.This draft guideline should be approved as a practice guideline.	77	4.2+/-1.12
22. If this draft guideline were to be approved as a practice guideline, I would use it in my own practice.	88	4.3+/-1.05
23. If this draft guideline were to be approved as a practice guideline, I would apply the recommendations to my patients.	88	4.3+/-1.05
Mean Approval rating/score	82	4.3+/-0.60

Note. Total of 6 questions were omitted from dataset due to need for reverse scoring (Questions # 1, 10, 13, 14 &15) and use of nominal level of measurement (Question #1).

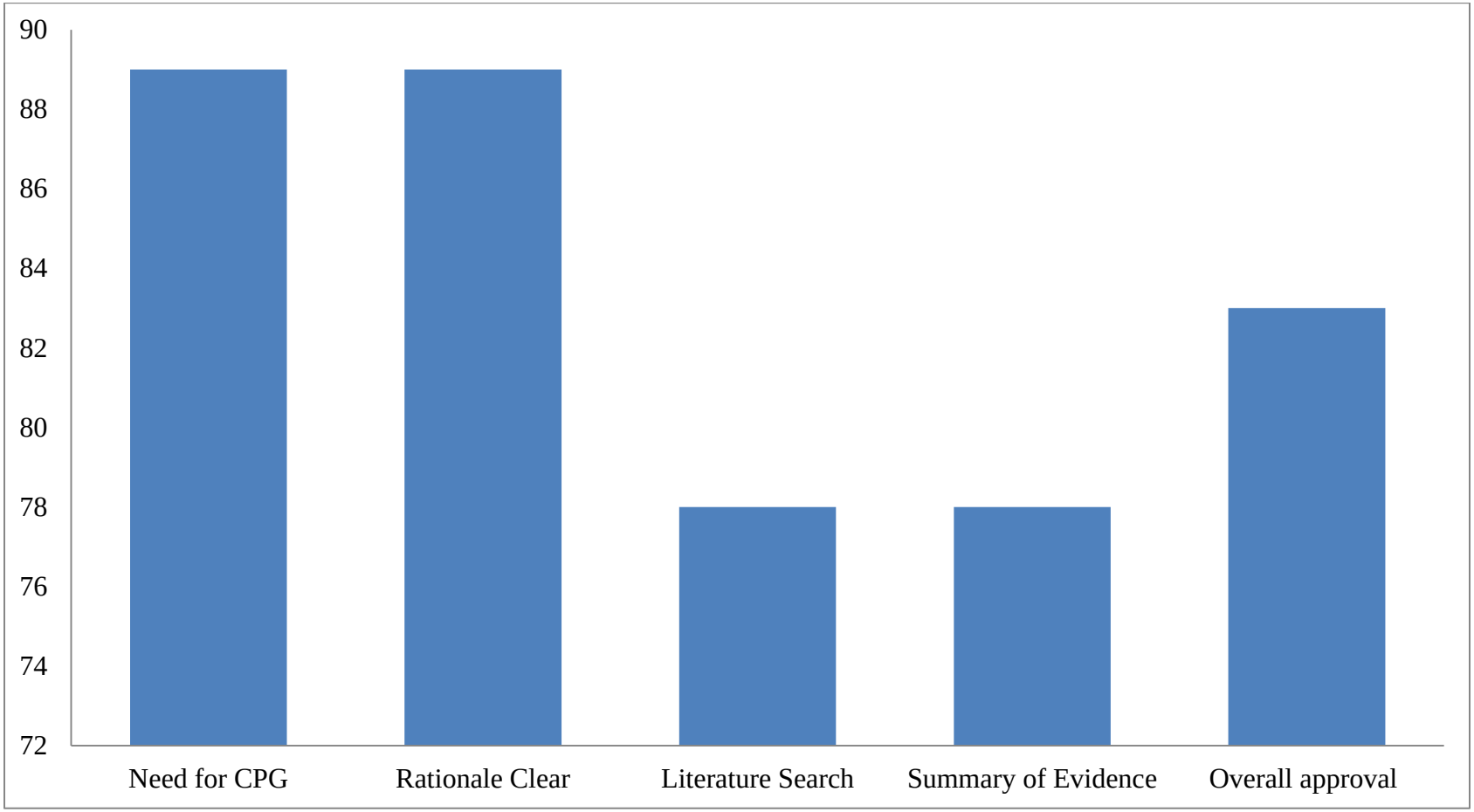

Figure 1.0 PFQ Percentage of quality rating for CPG

Appendix A

Table 1.0 *PH Intraoperative management literature review evidence rating table*

Author, year	Study objective/intervention or exposures compared	Design	Sample (N)	Outcomes studied (how measured)	Results	*Level and Quality Rating
Bennett, et al., (2013)	To put forth recommendations for the anesthetic management of patients with PH and intra-cardiac shunts and Eisenmenger syndrome (Bennett et al., 2013)	Retrospective controlled trial	A review of the anesthetic management of 33 patients from 1991-2011 with known Eisenmenger syndrome, for a total of 53 procedures	Type of cardiac shunt, Right Heart Systolic Pressures, NYHA classification, type of surgery, type of anesthesia, 2DEcho and right heart catheterization data, vasopressor use, monitoring data and 30 day mortality rate	A total of 36 general anesthetics, 13 monitored anesthesia cases, and two regional cases where preformed. Two additional cases began as monitored anesthesia care (MAC) cases and converted to general anesthesia. Two deaths occurred within 30 days of the procedure, both of these deaths occurred after MAC cases. There was a trend toward use of more invasive monitoring if etomidate is used. Desaturation occurred in six procedures, 4 of which were MAC cases. Goals of anesthetic should be to maintain SVR, and avoid	3C

					hypotension. Propofol had the highest incidence of hypotension on induction when compared to etomidate or an inhalation induction.	
Lai et al., (2007)	Evaluate the perioperative adverse outcomes of patients with and without PH (Lai et al., 2007)	Control trial without randomization	62 Patients from 1999-2004undergoing non-cardiac surgery	Patients were screened via Echocardiography 30 days prior to surgery, those with PAP greater than 70 were enrolled and case matched with peers having normal PAP. Comorbidities, cardiac risk, type of anesthesia, type of monitoring and type of surgery were measured	Intraoperative adverse events were comparable between the two groups. All intraoperative events were transient and included bradycardia and hypotension. General anesthesia, neuraxial anesthesia and regional anesthesia was used for these cases and no differences in outcomes were associated between patients using varying anesthesia techniques.	3B
Minai et al., (2013)	The review outlines the	Review	73 studies from 1966-2011	N/A	The reviewers discusses surgical factors that can	7B

	pathophysiology of PH and describes the optimization of PH and RV function prior to surgery, and appropriate perioperative anesthetic management techniques (Minai et al,2013).				worsen PH including positive pressure ventilation, hypercarbia, hypoxia, acidosis, pain, airway instrumentation, fluid overload, and arrhythmias. The review recommends limiting benzodiazepines and narcotics as they may cause respiratory depression, hypercarbia, and increased PVR. Additionally the review cautions against hypotension, which could precipitate RV ischemia The authors suggest using Etomidate as an induction agent for its cardiac stability. However, propofol and sodium pentothal should be avoided because they decrease blood pressure. Ketamine maybe considered as it decreases PVR and increases SVR. Ventilation is recommended with low tidal volumes and low PEEP with frequent blood gas analysis. General anesthesia and regional anesthesia have both	

					been shown to be equally effective, with neither technique resulting in better patient outcomes. The review suggests that anesthesia providers avoid nitrous oxide because it may increase PVR and contribute to right-sided heart ischemia. Adequate analgesia to minimize autonomic response to pain is crucial. The suggested treatment for hypotension is norepinephrine or vasopressin. In the face of acute decompensation inhaled Nitric Oxide or prostacyclin should be used. If pharmacologic management is not adequate then an LVAD or IABP should be considered (Minai et al,2013)	
Pilkington, et at., (2015).	This review provides an evidence-based definition, classification, pathophysiology, diagnosis and treatment of	Review	44 research studies from 2003-2014	N/A	The reviewers defines Pulmonary Hypertension (PH) as an increase in mean pulmonary arterial pressure (PAP) ≥25 mmHg at rest, as determined by right heart catheterization. It classifies	7B

	pulmonary hypertension with a focus on the perioperative management and treatment of pulmonary hypertensive crises in a non-cardiac setting (Pilkington et al., 2015)				PH based on the 5 World Health Organization clinical classification groups. The review gives a detailed process of the pathogenesis of Pulmonary arterial Hypertension (PAH) as well as specific drug therapy that can be used for PAH. The review summarizes the research on the morbidity and mortality associated with PH for those undergoing non-cardiac surgery. The principles of anesthetic management are discussed including prevention of right ventricular failure, optimizing pulmonary circulation, and pharmacological options for induction and maintenance of anesthesia.	
Price, et al., (2009)	To describe a cohort of PH patients undergoing surgery and monitor their	Retrospective cohort study	Data from 28 patients with known diagnosis of PH who had undergoing general	Patient demographics, co-morbidities and New York	14 patients underwent general anesthesia with opioids and Propofol for induction and varying maintenance	4A

	perioperative management and postoperative outcomes (Price et al., 2009)		anesthesia and regional anesthesia for non-cardiac, non-obstetric surgery from 2000-2007 was collected.	Heart Association functional class and preoperative hemodynamic evaluation by right heart catheterization were recorded. Type of surgery, type of anesthesia, and operative time were examined as well as postoperative complications within 28 days of surgery (Price et al., 2009).	anesthetics. 11 patients underwent neuraxial anesthesia, either a spinal (2) or a combined spinal epidural (9). The remaining three patients underwent regional block with sedation. No patients required conversion to general anesthesia. There was no statistically significant difference between those who underwent general anesthesia or regional anesthesia. Those that underwent general anesthesia showed less hemodynamic impairment then those undergoing a regional approach. Two deaths occurred due to right heart failure and most of the participants who suffered from complications underwent major surgery (Price et al., 2009).	

Appendix B: DNP proposal Timeline

April 2016 – Submit proposal to committee members for approval

May 2016- Present Proposal to committee members

May 2016 Submit to UMB IRB and Hospital IRB for approval

September 2016 Implement project from September 2016-December 2016

- September 2016- Stage one, give Rough CPG to team and revise/develop CPG
- October 2016- Stage two, present CPG to anesthesia providers
- November 2016- Stage 3, Make revisions to CPG and present to anesthesia administration for feedback/approval

December 2016- Analyze, synthesize and evaluate data by January 2017.

February 2017 Submit final scholarly project manuscript to committee for review

February 2017 Present final scholarly project report to Committee

Appendix C: Clinical Practice Guidelines for the Anesthetic Management of Patients with Pulmonary Hypertension

Guideline Title: Clinical Practice Guidelines for the Anesthetic Management of Patients with Pulmonary Hypertension

Guideline Status: Guideline developed in 2016
The guidelines will be updated every 2 years, to reflect new information as it becomes available.

Scope

Disease/Condition(s): Confirmed Pulmonary Hypertension

Guideline Category Preoperative evaluation and risk assessment, Intraoperative Management, Postoperative care

Clinical Specialty: Anesthesiology

Intended Users: Nurse Anesthetists and Anesthesiologists within St. Agnes Hospital

Guideline Objective

To reduce the risk of adverse outcomes in adult patients with Pulmonary Hypertension who are undergoing non-cardiac surgery at St. Agnes Hospital by improving the perioperative management techniques anesthesia providers at this facility can utilized when caring for this vulnerable patient population

- Preoperative - Standardize the preoperative screening process
- Intraoperative - Utilize evidence-based practices to formulate anesthesia plan of care
- Postoperative - Avoid hemodynamic alterations and transfer care to an appropriate unit based on patient acuity
- Offer a standardized and uniform delivery of care for all anesthesia providers

Target Population

Adult patients (age 18 and over) with confirmed Pulmonary Hypertension (PH), as diagnosed by right heart catheterization, this population includes patients who have a Pulmonary Hypertension diagnosis in WHO classification Groups 1- 5

Note: These guidelines do not focus on patients with the following conditions: Eisenmenger syndrome, Cardiac Surgery, and Pediatric and Obstetric population

Major Outcomes Considered

Risk of adverse outcomes in patients with Pulmonary Hypertension such as:

- Right sided heart failure
- Respiratory arrest
- Hypoxemic events
- Dysrhythmias
- Sepsis
- Unexpected intensive care unit admission and prolonged hospital stay
- Acute congestive heart failure
- Intraoperative hemodynamic instability/ abortion of surgical procedures
- Renal failure
- Myocardial infarction
- Hemodynamic collapse

Methodology

Description of Methods Used to Collect/Select the Evidence: Evidence used in the development of these guidelines is based on an extensive literature review. Literature citations are obtained from PubMed, One Search, CINAHL, EBSCO, and Medline

State of the Literature: A literature review of published studies from 2005-2015 was conducted. The focus of the search were articles related to the perioperative management of adult patients with Pulmonary Hypertension. Search terms used included: Perioperative management, anesthesia, pulmonary hypertension, and right sided heart failure. Relevant practice guidelines, published by nationally-recognized medical societies, were examined to gain insight on current care recommendations. The

reference list from each publication was examined to locate primary sources and additional publications related to the topic. A total of 26 articles pertaining to the perioperative anesthetic management of PH patients were used in this review.

Inclusion Criteria: evidence published after 2004, cohort studies, integrated and narrative reviews, and articles written in English.

Exclusion Criteria: Pulmonary Hypertension patients due to left sided heart failure, patients with Eisenmenger syndrome, obstetrics and pediatric population, and Cardiac Surgery were excluded from this review

Limitations: The evidence lacked well-defined experimental designs or randomized controlled trials. Recommendations are limited by the lack of appropriately controlled studies due to ethical limitations and the many aspects of PH management in the perioperative period. Additionally, the diagnosis and definition of PH is inconsistent among studies, with some using Doppler echocardiogram and others using right heart catheterization to determine inclusion criteria. These limitations affect the ability to draw firm conclusions in several areas of the guideline. As such, expert opinions and case studies were also incorporated into care recommendations. A complete bibliography used to develop these guidelines is described below.

Methods Used to Assess the Quality and Strength of the Evidence

Rating Scheme for the Strength of the Evidence: (Melnyk & Fineout-Overholt, 2011)

Quality Rating Scheme: (Newhouse et al, 2007)

Methods Used to Formulate the Recommendations

The guidelines were developed by a Task Force of 4 members, consisting of an anesthesiologist and three Registered Nurses, acting as student project leaders.The Task Force developed the guidelines by means of a staged model. In the first stage, sources of evidence were acquired via literature review, and the evidence was graded using Melnyk & Fineout-Overholt's and Newhouse rating Scheme. The team of stakeholders then drafted guidelines based on the available evidence. After preliminary guidelines were developed, the Task Force used the AGREE II tool to evaluate the clinical practice guideline (CPG) draft. The second stage involved the collection of feedback from the staff of anesthesia providers at St. Agnes, who were asked to review and comment on the CPG draft developed by the Task Force via a Modified Practitioner Feedback survey. The Task Force then revised the CPG based on the feedback provided by anesthesia staff and determined potential barriers to implementation.

In the third stage, the revised CPG was submitted to the anesthesia department's administrator for review. After receiving administrator feedback, the CPG was once again revised, and submitted for final approval.

Description of Implementation Strategy:

Facilitators and Barriers

The cultural readiness of anesthesia providers for the implementation of a CPG was appraised using the Alberta Context Tool (ACT). The ACT is a 56-item, 5 point Likert scale tool, which assesses organizational context in eight domains: leadership, culture, feedback, formal interactions, informal interactions, connections among people, structural and electronic resources, and organizational slack (staffing, space and time) (Estabrooks et al., 2009). The psychometric properties of the ACT have been assessed via Cronbach's alpha, exploratory factor analysis, and analysis of variance for instrument reliability and validity (Estabrooks et al., 2009).

Facilitators of implementation were identified as: leadership, culture, formal interactions, structural and electronic resources, organization slack (staffing, space, time), and connections among people suggesting a robust staff dynamic. Barriers to implementation were found specifically in the areas of: formation of an action plan, monitoring performance/data audits, and interactions with research coordinators/research champions. This suggests that the anesthesia group, has limited experience with implementation projects, and thus may not know how to pilot such an endeavor; these barriers must be accounted for prior to CPG implementation.

Description of Method of Guideline Validation

The validity of the AGREE II tool and Browers' (2004) Practitioner Feedback Questionnaire (PFQ) has been well established. The AGREE tool was originally published in 2003 and then updated to the AGREE II tool in 2013 to maintain reliability and ensure validity (Brouwers, et al. 2010). The AGREE II tool consists of 23 items within 6 quality domains; each domain focuses on a specific feature of a clinical practice guideline (Brouwers, et al. 2010). The internal consistency measurement of the 6 domains demonstrated the reliability of the AGREE II tool with a Chronbach alpha score ranging from 0.64 to 0.89 (Brouwer et al., 2010). The PFQ has a good construct and internal validity and reliability with Cronbach alpha coefficients

ranging from 0.75 to 0.85. The PFQ also utilizes measures such as respondent exclusion following questionnaire answers that are ambiguous or neutral in order to improve internal consistency. The PFQ tool is composed of 23 items that are assessed using a 5-point Likert scale (5=strongly agree, 1=strongly disagree).

Major Recommendations

I. Preoperative Evaluation

- The anesthesia provider should collaborate with surgeons to develop a protocol whereby patients with Pulmonary Hypertension (PH) are evaluated before the day of surgery to allow the sufficient preparation of a perioperative management plan.
    - If a patient has a known PH diagnosis, a consultation should be initiated by the operating surgeon by contacting the anesthesia department to coordinate a formal evaluation before the scheduled surgery
- A preoperative evaluation should include a comprehensive evaluation of the patient's medical history and review of previous medical records (if available), a thorough physical assessment and interview with the patient and/or family [7, 11, 19, 25]
    - Evaluation of medical history and previous records should include (but not be limited to) checking for the presence and subsequent treatment of coexisting comorbidities
        - Especially conditions affecting the cardiovascular and pulmonary systems (i.e. pulmonary embolism (PE), coronary artery disease (CAD), and chronic kidney disease (CKD)) and other congenital or acquired medical conditions [18, 19, 25]
        - Determine underlying etiology of PH diagnosis (See *Appendix A* for The World Health Organization's (WHO) Clinical Classification of PH) [6, 15, 19]
            I. The clinical classification will guide the therapy selection and overall management during the perioperative phase [4, 25]
- Assess current medication regimen, specifically those prescribed for chronic PH therapy
- Review findings of preoperative echocardiogram, laboratory results, electrocardiogram (EKG) and right heart catheterization (RHC) (if indicated) [11, 15, 18, 19]
    - Chest radiographs, thoracic computed tomography (CT) scanning and pulmonary function tests are beneficial in the presence of coexisting lung disease or a worsening respiratory status [6, 25]

- A physical examination should include an evaluation of the lungs, heart, kidneys, and vascular system functionality [7]
    - Assess for episodes of dyspnea, syncope, angina, arrhythmias, shortness of breath, hemoptysis, fatigue, and symptoms associated with right heart failure (e.g. jugular vein distention, ascites, peripheral edema, and hepatomegaly) [6, 7, 11]
- The patient and family interview should focus on questions related to severity of PH and right ventricular functionality, such as functional capacity (METs), exercise tolerance, how previous surgeries were tolerated and recent changes in health or symptom development [15, 25]
- Given the elevated perioperative morbidity and mortality risk associated with PH, anesthesia providers must carefully weigh the risks and potential benefits of the surgery [15, 25]
    - Inform the patient and his or her family about increased risk for potential complications, that can range in severity based on their current health condition and right ventricular functionality
        - Discuss code status and establish health care proxy (*per the facility's policy*) [25]
    - Evaluate for potential predictors associated with an increased perioperative morbidity and mortality
        - The following patient and surgery related features have been identified as significant risk factors responsible for an increased morbidity and mortality in PH patient population undergoing surgery: medical history of a PE, CAD, CKD, an American Society of Anesthesiologists (ASA) physical classification status > 2, New York Heart Association (NYHA) functional class of 3 or 4, emergency surgery or surgeries classified as intermediate or high risk, procedures that last longer than 3 hours, intraoperative vasopressor use, right axis deviation on EKG, right ventricular hypertrophy, elevated mPAP and right atrial pressure, and a 6MWD < 300-399 meters prior to surgery. [4, 6, 7, 9, 14, 15, 22, 25]
- If any characteristics noted during the preoperative evaluation suggest that the patient has PH but has not been formally diagnosed, the anesthesia provider should notify appropriate anesthesia providers (Chief and floor leader), as well as the surgeon and discuss whether to (1) manage the patient perioperatively based on clinical criteria alone or (2) postpone surgery to obtain further testing.
    - Elective procedures should be cancelled to allow the underlying condition to be adequately evaluated and managed before rescheduling [19]
    - RHC is needed to confirm PH diagnosis, assess severity, and guide therapeutic decisions [5-7, 15, 19]

Key point: The preoperative evaluation should incorporate a risk assessment which takes into consideration the patient's functional status, the type of surgical procedure and its length, the severity of the disease state based on their current comorbidities and the

function of their right ventricle (RV). [5, 11]

II. Preoperative Preparation and Optimization

- Utilize a multidisciplinary team approach when coordinating care [7, 11, 15, 19, 25]
    - Notify Cardiologist, ICU attending, chief anesthesiologist/ anesthesia floor leader, Clinical Nurse Specialist (CNS) in OR and ICU and pharmacist of PH patient undergoing surgery
- Based on patient's medical history and physical assessment, a functional classification can be determined (See *Appendix B* for NYHA/WHO Functional Classification of PH) [7, 19]
- Assess patient's exercise capacity using the six-minute walking test distance (6MWD)
    - Exercise capacity is significantly influenced by the functional status of the RV [6]
    - A reduced total distance (<300-400 meters) correlates with a higher mortality risk [5, 19, 25]
- Avoid factors that can aggravate PH in the preoperative area: anxiety, pain, sympathetic stimulation, hypoxia or hypoventilation, acidosis, and hypervolemia [15]
- Medications prescribed to treat PH should be continued throughout the perioperative period (11, 18, 19)
    - Consult with cardiologist regarding anticoagulant therapy prior to surgery
        - Hold Warfarin 5 days before surgery without bridging to heparin unless indicated (i.e. PE, PH class IV, mechanical heart valve) [11, 15, 19]
    - Verify that the facility can adequately cover the patient's PH medication needs [25]
        - Patients receiving continuous infusions or nebulized prostacyclins for chronic PH therapy should be transferred to UMMC to undergo surgical evaluation
- Preoperative testing should include:
    - Laboratory blood tests
        - Full set of labs to be completed within 30 days of scheduled procedure
        - Complete blood count, comprehensive metabolic panel, coagulation studies, arterial blood gas, and B-type natriuretic peptide (if available) [6, 19]
        - B-type natriuretic peptide (BNP): a sensitive biomarker released in response to ventricular stretch/strain; serum levels correlate with the degree of cardiac stress, reflecting the extent of right ventricle dysfunction [6, 25]
            - An elevated BNP from PH patient's baseline is associated with an increased mortality [25]
            - BNP <100 pg/mL typically indicates the absence of heart failure
    - Electrocardiogram

        - To be completed within 6 months of scheduled procedure
        - Arrhythmias can negatively impact cardiac output causing further deterioration [6]
    - Echocardiogram
        - Obtain the patient's most recent Echo report
        - An acceptable timeframe in which the report was completed is patient dependent and must be determined by St. Agnes Cardiologist
        - Monitors disease progression and severity, assesses the size and function of the ventricles and valves, calculates ejection fraction, and offers RV pressure estimate by indirectly measuring right ventricle systolic pressure (RVSP) [5-7, 18]
        - The RVSP measurement is an approximation that can potentially report inaccurate pulmonary artery pressures (due to over or underestimating) [6, 25]
    - Right heart catheterization
        - Need for RHC must be determined by St. Agnes Cardiologist
        - Not routinely needed unless indicated by recent decompensation in functional status or inconsistent preoperative test results regarding the overall status and function of the right side of the heart [6, 15, 25]
        - RV dysfunction should indicate the need for surgery to be postponed to allow initiation of medical management techniques to improve RV function [11, 15]
- Risk assessment for 1-year mortality in PAH: [6]
    - **Low risk (< 5%):** NYHA functional class I or II, reports no syncope episodes, 6MWD >440m, RA area <18cm2, no pericardial effusions, RAP <8mmHg, CI >2.5 l/min/m2, Sv02 >65%
    - **Intermediate risk (5-10%):** NYHA functional class III, reports occasional syncope, 6MWD 165-440m, RA area 18-26cm2, none to minimal pericardial effusion, RAP 8-14mmHg, CI 2.0-2.4 l/min/m2, Sv02 60-65%
    - **High risk (>10%):** NYHA functional class IV, reports repeated syncope episode, 6MWD <165 m, RA area >65cm2 and pericardial effusion, RAP >14mmHg, CI <2.0 l/min/m2, Sv02 <60%

Key Point: Overall objective is to optimize the patient's current state of health as much as possible to maintain the baseline function of the RV and minimize the risk of complications [7, 19, 25]

Key Point: Effective communication between all members of the multidisciplinary team and the patient is imperative in order to establish realistic expectations for the patient and/or family and facilitate a smooth transition of care throughout the perioperative phase (25)

III. **Intraoperative Management Principles**

· Due to the fragility of the PH population and the heightened surgical risk all anesthetic goals should focus on the maintenance of right ventricular function and avoidance of PH crises. [3,15,17, 19-21, 23, 24, 26]

· Regardless of type of anesthetic used, the practitioner should uphold the following principles: Maintain systemic vascular resistance (SVR), and prevent an increase in pulmonary vascular resistance (PVR) [3,15,17, 19-21, 23, 24, 26]

· Attempt to maintain euvolemia. Fluid overload must be avoided in this population as it propensities right sided heart failure. [15,17,19-21, 23, 24, 26]

· Maintain Normal Sinus Rhythm. PH patients poorly tolerate the arrhythmias, and loss of atrial kick [6, 23-24]

· Certain surgical procedures present a higher risk to PH patients these include: surgeries associated with major blood loss, pneumoperitoneum, venous air, carbon dioxide, fat or cement embolism, or loss of lung blood vessels. The anesthesia provider should be aware that these surgeries hold a higher risk and prepare accordingly. [15, 17]

Key Point: Efforts should be aimed at maintaining SVR and NSR and avoiding: respiratory depression, hypoxemia, hypercapnia, hypotension, hypothermia, acidosis, fluid overload and pain. [15, 17, 19-21, 23, 24, 26]

Modes of Anesthesia

· During the Preoperative work-up anesthesia providers must consider the risk benefit ratio of the type of anesthesia, surgical implications on fluid balance/shifts, account for potential increases in PVR, and the tools that are available to treat PH and acute right ventricular failure. [15,17,19]

· There is no strong evidence to support one type of anesthetic has an influence on morbidity and mortality, although some studies have found more adverse outcomes in patients who undergo IV sedation [3]

· Regardless of the mode of anesthesia, the above management principles should be upheld

Key Point: Any anesthetic approach may be used as long as hemodynamic instability is avoided, rapidly recognized, and corrected [3, 15, 17, 19-21, 23, 24, 26]

Local Anesthesia

· For minimally invasive or superficial procedures, consider the use of local anesthesia or peripheral nerve blocks, without IV sedation. [3, 15,17, 23]

· If IV sedation is used, ventilation should be continuously monitored by capnography, because hypercapnia must be avoided in PH patients. [3, 15, 17, 19-21, 23, 24, 26]
  ○ General anesthesia with a secure airway is preferable to deep MAC sedation without a secure airway due to the deleterious effects of hypercapnia in this population. [3,17, 20, 23]

Neuraxial Anesthesia

· Neuraxial anesthesia (spinal/epidural) should be considered for procedures on the lower extremities[3, 14, 15,17, 19-21, 23, 24, 26]
· The sympathectomy associated with spinal anesthesia makes this a relative contraindication for this population, and an epidural is preferred due to less rapid hemodynamic alterations. [6, 15,17, 19-21]
· If the practitioner deems a spinal anesthesia to be appropriate the rapid peripheral vascular dilation and hemodynamic alterations associated with this method must be avoided. [15,17, 19-21]

Key Point: The consensus in the literature is that regional anesthesia is a better tolerated anesthetic then general anesthesia for PH patients and should be used if the type and duration of surgery allows [3, 14, 15, 17, 19-21, 23, 24, 26]

General Anesthesia

· General anesthesia is the preferred method of anesthesia if the provider anticipates a longer surgery or excessive blood loss [15, 17]
· For general anesthesia, the sympathetic response to direct laryngoscopy may cause a rapid increase in right ventricular afterload and must be avoided. [15, 17, 19-21, 23, 24, 26]
· Adequate depth of anesthesia should be achieved before airway instrumentation is attempted [15, 17, 19-21, 23, 24, 26]
· Before intubation, a plan to rapidly secure the airway must be made due to the patient's inability to tolerate a period of hypoxia or poor ventilation [15,17, 19-21]
· The patient should be pre-oxygenated with 100% FiO2 until the ETCO2 is above 90% to mitigate the risk of hypoxemia due to reduced FRC [15]

Induction Medications

· The anesthesia provider should maintain a judicious use of benzodiazepines during the perioperative phase. Consideration of the patient’s need for anxiolytics should be weighed against the patient’s ability to tolerate sedation. [15, 17, 19]

· Etomidate is preferable to Propofol as an induction agent in that it preserves SVR with little effect on PVR [3,15, 17, 19-23]
· Propofol and Thiopental directly decrease SVR and cardiac contractility and should be avoided in this population [15,17,19]
· Opioids have been shown to have minimal effect on pulmonary vasculature and should be used to minimize the sympathetic response to direct laryngoscopy, and to decrease the dose of other anesthetic medications [15,17,19, 24]
· Nitrous Oxide causes increases in PVR, and can potentiate right heart ischemia therefore this drug should be avoided in the PH patient population [15, 17, 19-20]
· There is controversial data about the effects of inhalation agents on pulmonary vasculature and their effects on PVR, however, sevoflurane seems to be the most favorable of the volatile agents in producing vasodilation of the pulmonary vasculature. [10, 17, 19-20]

Key Point: Etomidate and use of an opioid is the induction method of choice in this population. [3, 15, 17, 19- 23] Maintenance of anesthesia with sevoflurane seems to be the most favorable of the volatile agents in producing vasodilation of the pulmonary vasculature. [10, 17, 19]

Intraoperative Monitoring

· No recommendations consistently support the use of a specific invasive monitor however the benefits of an arterial line in allowing the anesthesia provider to quickly recognize hemodynamic changes, and allows access to frequent arterial blood gas analysis have consistently been documented. [3, 15, 17, 19, 24]
· Awake arterial line placement will give anesthesia providers a useful tool to monitor SVR on induction [3, 19]
· The risks associated with placement of a Pulmonary Artery Catheter (SWAN GANZ) do not justify placement, except in the most severe cases of PH or during a high risk procedure or where calculation of PVR will be used to guide vasodilator therapy [3, 15, 19] Additionally, due to the potential presence of shunts and tricuspid regurgitation Cardiac Output monitoring via thermodiluation may be unreliable [22] and a PA catheter is not routinely recommended.
· The placement of a central line for monitoring of central venous pressures may not be accurate in patients with PH. [15, 24]
· Intraoperative trans-esophageal echocardiography (TEE) should be considered for guiding fluid management, and assessing the right ventricle. This should be considered in patients with severe PH, or those undergoing major or prolonged surgery (greater than 3 hours). However, TEE insertion can cause sympathetic response so the patient must have significant depth of anesthesia prior to insertion [15, 17]

· Elevations in Right arterial pressure and a reduction in cardiac output are of more concern than pulmonary artery pressures alone, because they indicate acute RHF. [15] A NICOM should be used for all PH patients presenting for surgery, so that SV and CO can continuously be monitored.

Key Point: An arterial line offers anesthesia providers a quick and reliable way to measure SVR, and is indicated for all but the lowest risk surgeries [3, 15, 17, 19, 24]

Ventilation

· All patients should be given oxygen therapy as it acts as a potent pulmonary vasodilator, oxygenation should be monitored and maintained throughout the operative course [15, 19]
· Positive pressure ventilation can impede venous return, reduce preload, limit CO, over distend the alveoli and increased PVR [15, 23, 24]
· Lung protective strategies should be utilized in this population and positive pressure ventilation should use low tidal volumes (6mL/kg) and low PEEP (less than 10) while adjusting respiratory rate to prevent hypercarbia. [15,17, 23, 24]
· After placement of endotracheal tube, bilateral breath sounds must be verified. Single lung ventilation is poorly tolerated in this population and could precipitate a PH crises [15,17]
· Full reversal of neuromuscular blockade should be verified before extubation, to ensure the patient has full and adequate use of the diaphragm. Reduced muscular function may cause hypercapnia, hypoxia and acidosis and precipitate right sided heart failure

Key Point: Ventilation should use low tidal volumes (6mL/kg) and low PEEP (less than 10) while preventing hypercarbia and hypoxia [15, 17, 23, 24]

Hemodynamic Support and Management of PH Crises

· Avoid bradycardia or tachycardia. Attempt to maintain a stable NSR. Patients with new onset atrial dysrhythmias have greater risk of mortality and should be rapidly cardioverted to prevent deterioration. [6, 23]
· Right ventricle volume overload due to fluid shifts of surgery may reduce LV capacity size, compromise filling and decrease CO, leading to hypotension [15] Hypovolemia and hypervolemia are both poorly tolerated and it is necessary to maintain euvolemia throughout the operative course/ [20, 23]
· Trial 250 mL fluid boluses based on NICOM or CVP reading. Discontinue boluses if no improvements in CO are seen [23, 24]

· Sympathomimetic vasopressors may be necessary to maintain adequate SVR, and should be initiated as soon as hypotension is recognized [3,15, 21, 24]
· Consider giving a vasopressor prior to induction to prevent a decrease in SVR [3]
· When SVR is low a combination of inotropic support and vasopressor agent such as norepinephrine or vasopressin is recommended [15]
· In the face of acute decompensation, measures should be taken to reduce PVR. Aggressive measures to reduce PVR may be warranted if systemic hypotension is paired with an increase in right atrial pressure, indicating RV afterload is the problem [15, 24]
· DoBUTamine and milrinone are ionodilators that reduce PVR, but they may require additional vasopressors to maintain SVR [6, 23, 24]
· Epinephrine, dopamine, norepinephrine and isoproterenol have been shown to increase cardiac contractility [15, 19, 24]
· Levosimendan (a new dual-acting , non-arrhythmogenic calcium sensitiser) have been shown effective in the treatment of right sided heart failure. [15, 19]
· Pulmonary artery vasodilation can be achieved with intravenous nitroglycerin or sodium nitroprusside if systemic hypotension is accounted for [23]
· The use of inhaled nitric oxide, prostacyclin, or parenteral sildenafil should be used to acutely reduce PVR. [15, 17,19]
· Inhaled agents combined with intravenous inotropes may be more beneficial than either class of medication used alone. [15, 17,19]
· If pharmacologic management is not adequate to maintain hemodynamics then a surgically implanted device, such as an intra-aortic balloon pump, or left ventricular assist device for hemodynamic support should be considered. [15, 17]

Key Point: Maintain NSR and Euvolemia, rapidly correct hemodynamic alterations using available vasopressors, iontropes and pulmonary vasodilators.

IV. Postoperative Management

- Regional analgesic techniques or other pain management modalities such as a patient controlled analgesia (PCA) should be considered for postoperative pain control [8,9, 21]
- If patient-controlled systemic opioids are used, continuous background infusions should be avoided or used with extreme caution to avoid respiratory depression and potential hypercapnia and hypoxia [8,9,21,26]
- Supplemental oxygen should be administered continuously to all PH patients until they are able to maintain their baseline oxygen saturation on room air [10,13,19]

- When cardiac arrhythmias, inadequate respiratory function or other hemodynamic instabilities are noted postoperatively, patients must be transferred to the intensive care unit for up to 24 hours for minor surgeries and up to several days following major surgeries.[20,21,26]
- If possible, PH patients facing increased perioperative risks should be placed in the intensive care unit for close monitoring where early signs of hemodynamic instabilities will be recognized and acted upon.[9,10,13,19,26]
- Postoperative reintubation should be avoided as much as possible. If and when reintubation is not avoidable, prophylactic administration of vasopressors is indicated in order to augment systemic blood pressure and avoid a steep decrease in SVR[10,19,26]
- Hospitalized PH patients who are at an increased risk of respiratory compromise should have continuous pulse oximetry monitoring after discharge from the recovery room.[13,19,26]
- If frequent or severe airway obstruction or hypoxemia occurs during postoperative monitoring, initiation of nasal CPAP or noninvasive positive pressure ventilation should be considered.[20,21,26]
- Pharmacological treatments that pulmonary hypertension patients were on preoperatively should be continued during the postoperative phase [9,19,20,26]
    - Prostacyclin analogues
    - Endothelin receptor antagonists
    - Phosphodiesterase-5 inhibitors (Sildenafil, Tadalafil)

Key Point: Patients with pulmonary hypertension are at risk of developing elevated pulmonary pressure and right-sided heart failure not only during the perioperative phase itself, but also in the postoperative course. These patients should therefore be placed under intense postoperative monitoring for a period appropriate to the degree of surgical trauma; the target monitoring time should be between 24 hours for small interventions and several days for major procedures (abdominal and thoracic surgery, major urological interventions). Depending on the patient's initial condition (functional classification), hemodynamic monitoring may need to be continued postoperatively until pulmonary pressures, and right-sided heart functions have stabilized at the preoperative level.

Clinical Algorithm(s) : Pending

Evidence Supporting the Recommendations: Management recommendations in this guideline are based off narrative and integrative reviews, retrospective cohort studies, opinion-based evidence, and the input of pulmonologists and cardiologists with expertise in the field of PH

(See bibliography)

Benefits/Harms of Implementing the Guideline Recommendations: The potential benefits of implementing this CPG include: improved perioperative care and reduced risk of perioperative morbidity and mortality in adult patients with Pulmonary Hypertension who receive anesthesia services from providers at St. Agnes Hospital.

Potential Harms: None indicated

Qualifying Statements : Practice guideline recommendations based off evidence that the practitioner may use to guide decisions about health care in the clinical setting. These recommendations may be adopted, modified, or rejected according to clinical needs and constraints, and are not intended to replace local institutional policies.

Source(s) of Funding : None

Identifying Information
Guideline Committee: Task Force on Perioperative Anesthetic Management of Patients with Pulmonary Hypertension

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Appendix D: Modified Practitioner Feedback Survey

For each item, please check off the box that most adequately reflects your opinion

Please list demographic data			
CRNA MDA	Gender Male Female		
Years practiced in current role <5 5-10 10-15 15-20 20-25 >25 Years at current hospital <5 5-10 10-15 15-20 20-25 >25	Ethnicity AA CAUC OTHER		
Age 20-30 30-40 40-50 50-60 60-70			
1. Are you responsible for the care of patients for whom this draft guideline report is relevant? This may include the referral, diagnosis, treatment, or follow-up of patients.	Yes ☐	No ☐	Unsure ☐

If you answered "*No*" or "*Unsure*", there is no need to answer or return this questionnaire. If you answered "*Yes*", please answer the questions below and return to **[enter expected destination of surveys]**.

(1=Strongly Disagree - 5= Strongly Agree)	1	2	3	4	5
2. The rationale for developing a guideline is clear.	☐	☐	☐	☐	☐
3. There is a need for a guideline on this topic.	☐	☐	☐	☐	☐
4. The literature search is relevant and complete (e.g., no key evidence was missed nor any included that should not have been) in this draft guideline.	☐	☐	☐	☐	☐
5. I agree with the methodology used to summarize the evidence included in this draft guideline.	☐	☐	☐	☐	☐
6. The results of the evidence described in this draft guideline are interpreted according to my understanding of the evidence.	☐	☐	☐	☐	☐

7. The draft recommendations in this report are clear.	☐	☐	☐	☐	☐
8. I agree with the draft recommendations as stated.	☐	☐	☐	☐	☐
9. The draft recommendations are suitable for the patients for whom they are intended.	☐	☐	☐	☐	☐
10. The draft recommendations are too rigid to apply to individual patients.	☐	☐	☐	☐	☐
11. When applied, the draft recommendations will produce more benefits for patients than harms.	☐	☐	☐	☐	☐
12. The draft guideline presents options that will be acceptable to patients.	☐	☐	☐	☐	☐
13. To apply the draft recommendations will require reorganization of services/care in my practice setting.	☐	☐	☐	☐	☐
14. To apply the draft guideline recommendations will be technically challenging.	☐	☐	☐	☐	☐
15. The draft guideline recommendations are too expensive to apply.	☐	☐	☐	☐	☐
16. The draft guideline recommendations are likely to be supported by a majority of my colleagues.	☐	☐	☐	☐	☐
17. If I follow the draft guideline recommendations, the expected effects on patient outcomes will be obvious.	☐	☐	☐	☐	☐
18. The draft guideline recommendations reflect a more effective approach for improving patient outcomes than is current usual practice. (If they are the same as current practice, please tick NA). *NA* ☐	☐	☐	☐	☐	☐
19. When applied, the draft guideline recommendations will result in better use of resources than current usual practice. (If they are the same as current practice, please tick NA). *NA* ☐	☐	☐	☐	☐	☐
20. I would feel comfortable if my patients received the care recommended in the draft guideline.	☐	☐	☐	☐	☐
21. This draft guideline should be approved as a practice guideline.	☐	☐	☐	☐	☐
22. If this draft guideline were to be approved as a practice guideline, I would use it in my own practice.	☐	☐	☐	☐	☐
23. If this draft guideline were to be approved as a practice guideline, I would apply the recommendations to my patients.	☐	☐	☐	☐	☐

Adapted from: Brouwers, M.C., Graham, I.D., Hanna, S.E., Cameron, D.A., & Browman, G.P. (2004). Clinicians' assessments of practice guidelines in oncology: The CAPGO survey**.** *International Journal of Technology Assessment in Health Care, 20*(4), 421-6.

Appendix E: Non-human subjects research determination

Date: June 6, 2016

To: Richard Muwowo, M.D

Name: RPN # 2016-019- Clinical Practice Guidelines for the Anesthetic Management of Patients with Pulmonary Hypertension

This letter is to acknowledge that the Saint Agnes IRB reviewed the information provided and has determined that the submission does not require IRB review. This determination has been made with the understanding that the proposed project does not involve a systematic investigation designed to develop or contribute to generalizable knowledge OR a human participant (see below).

This determination applies only to the activities described in the IRB submission and does not apply should any changes be made. If changes are made and there are questions about whether these activities are human subject research in which the organization is engaged, please submit a new request to the IRB for a determination.

Appendix F: Agree II tool

DOMAIN 1. SCOPE AND PURPOSE

1. The overall objective(s) of the guideline is (are) specifically described.

1 Strongly Disagree	2	3	4	5	6	7 Strongly Agree

Comments

2. The health question(s) covered by the guideline is (are) specifically described

1 Strongly Disagree	2	3	4	5	6	7 Strongly Agree

Comments

3. The population (patients, public, etc.) to whom the guideline is meant to apply is specifically described.

1 Strongly Disagree	2	3	4	5	6	7 Strongly Agree

Comments

DOMAIN 2. STAKEHOLDER INVOLVEMENT

4. The guideline development group includes individuals from all relevant professional groups

1 Strongly Disagree	2	3	4	5	6	7 Strongly Agree

Comments

5. The views and preferences of the target population (patient, public, etc.) have been sought.

1 Strongly Disagree	2	3	4	5	6	7 Strongly Agree

Comments

6. The target users of the guideline are clearly identified.

1 Strongly Disagree	2	3	4	5	6	7 Strongly Agree

Comments

DOMAIN 3. RIGOUR OF DEVELOPMENT

7. Systematic methods were used to search for evidence.

1 Strongly Disagree	2	3	4	5	6	7 Strongly Agree

Comments

8. The criteria for selecting the evidence are clearly described.

1 Strongly Disagree	2	3	4	5	6	7 Strongly Agree

Comments

9. The strengths and limitations of the body of evidence are clearly described.

1 Strongly Disagree	2	3	4	5	6	7 Strongly Agree

Comments

10. The methods for formulating the recommendations are clearly described.

1 Strongly Disagree	2	3	4	5	6	7 Strongly Agree

Comments

11. The health benefits, side effects, and risk have been considered in formulating the recommendations.

1 Strongly Disagree	2	3	4	5	6	7 Strongly Agree

Comments

12. There is an explicit link between the recommendations and the supporting evidence.

1 Strongly Disagree	2	3	4	5	6	7 Strongly Agree

Comments

13. The guideline has been externally reviewed by experts prior to its publication.

1 Strongly Disagree	2	3	4	5	6	7 Strongly Agree

Comments

14. A procedure for updating the guideline is provided.

1 Strongly Disagree	2	3	4	5	6	7 Strongly Agree

Comments

DOMAIN 4. CLARITY OF PRESENTATION

15. The recommendations are specific and unambiguous.

1 Strongly Disagree	2	3	4	5	6	7 Strongly Agree

Comments

16. The different options for management of the condition or health issue are clearly presented.

1 Strongly Disagree	2	3	4	5	6	7 Strongly Agree

Comments

17. Key recommendations are easily identifiable.

1 Strongly Disagree	2	3	4	5	6	7 Strongly Agree

Comments

DOMAIN 5. APPLICABILITY

18. The guideline describes facilitators and barriers to application.

1 Strongly Disagree	2	3	4	5	6	7 Strongly Agree

Comments

19. The guideline provides advice and/or tools on how the recommendation can be put into practice.

1 Strongly Disagree	2	3	4	5	6	7 Strongly Agree

Comments

20. The potential resource implications of applying the recommendations have been considered.

1 Strongly Disagree	2	3	4	5	6	7 Strongly Agree

Comments

21. The guideline presents monitoring and/or auditing criteria.

1 Strongly Disagree	2	3	4	5	6	7 Strongly Agree

Comments

DOMAIN 6. EDITORIAL INDEPENDENCE

22. The views of the funding body have not influenced the content of the guideline.

1 Strongly Disagree	2	3	4	5	6	7 Strongly Agree

Comments

23. Competing interests of guideline development group members have been recorded and addressed.

1 Strongly Disagree	2	3	4	5	6	7 Strongly Agree

Comments

OVERALL GUIDELINE ASSESSMENT

1. Rate the overall quality of this guideline.

1 Strongly Disagree	2	3	4	5	6	7 Strongly Agree

Comments

2. I would recommend this guideline for use