Comparing Patient Systolic Blood Pressures with Tourniquet Inflation pressures and the Effects on Estimated Blood Loss. (A retrospective chart review)

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Abstract

During surgical interventions of upper or lower extremities, one of the methods in which blood loss can be decreased is through application of the pneumatic tourniquet. A bloodless field provides important advantages for the surgeon, and the pneumatic tourniquets provide a relatively good bloodless field to minimize intraoperative blood loss. (Naglehout & Elisha, 2018). Recent literature supports the use of personalized tourniquet inflation pressures (PTIP) as opposed to universal tourniquet inflation pressures. (UTIP)

The purpose of this DNP project was to investigate what systolic blood pressures were measured on patients undergoing lower extremity surgeries prior to tourniquet inflation, what tourniquet inflation pressures were being used, and determine whether these tourniquet inflation pressures conform with PTIP, or UTIP standards, and further determine their effects on estimated blood loss (EBL), and other tourniquet related complications.

This project comprises of a retrospective review of patient charts. A total of 186 electronic anesthesia records were reviewed and 75 patients were included in the DNP project.

Identification of a project site was the first step. Approval was sought from the health facility and the various internal review boards (IRBs). A retrospective chart review was conducted to examine three full months of surgeries involving the lower extremities which required the use of pneumatic tourniquets. Data was collected and subsequently analyzed by use of Microsoft Excel. This data included the systolic blood pressures of patients prior to tourniquet inflation, tourniquet inflation pressures, ASA physical status, patient BMI, age and Gender.

By completion of this retrospective chart review, it has been discovered that 75 patients received lower extremity surgeries with the use of pneumatic tourniquets. Of the 75 patients, tourniquets were inflated to 275mmHg on 57 (76%) of them regardless of their systolic blood

pressure (SBP). 63 patients (84%) had a recorded EBL less than 100mL. No tourniquet related complications were recorded. Only one patient (1.3%) had a tourniquet inflation pressure greater than 300mmHg, with EBL recorded at 10mL.

Keywords: Tourniquet inflation pressure, systolic blood pressure, estimated blood loss.

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Background

Despite the benefits to the surgeon, pneumatic tourniquets can cause multiple complications if specific criteria are not followed in their application. Some specific complications include tourniquet pain, hypertension, and postoperative neurapraxia. Evidence of nerve injury at the skin level at the edge of the tourniquet has also been reported. (Naglehout & Elisha, 2018). One significant safety measure for preventing tourniquet related complications is ensuring that only minimally effective pressure is used for occluding blood flow to the extremity. According to Naglehout and Elisha, tourniquet pressures for upper extremity should be kept at 70-90 mmHg more than the patients systolic blood pressure, and that of the lower extremity should be kept at twice the patient's systolic blood pressure or 300mmHg if twice the systolic is less. For the purposes of this research, focus will be placed solely on lower extremity surgeries.

Problem Statement

In actual practice however, some surgeons have requested tourniquet pressures much higher than these thresholds. Surgeons commonly inflate lower extremity tourniquets to a standard pressure of 350mmHg. (Kim & Kim, 2018). These practices are not ideal as according to Kim and Kim, there have been cases of tourniquet related complications such as nerve damage following the use of standard inflation pressures, which can be significantly high for some patients. There have also been multiple case reports of cardiac arrest following pneumatic tourniquet deflation after lower extremity tourniquets inflation to 350mmHg for one hour and forty-five minutes. (Spruce, 2017).

Needs Assessment/Organizational "Gap" Analysis

There is the need for an individualized tourniquet inflation pressure tailored to each patient based on systolic blood pressure, limb circumference and limb occlusion pressure. (Spruce, 2017). Other factors that should be considered for the safe application of tourniquets, based on individual needs rather than using facility standard tourniquet inflation pressures include; patient's age, skin, shape and size of the extremity, and the dimensions of the cuff being used. (Kumar et al, 2016). According to Ding et al., (2019), the individualized pressure setting strategy can provide a lower inflation pressure (four studies), improve hemostatic effect (six studies) and reduce the incidence of related complications in patients undergoing orthopedic surgery.

It has therefore become imperative to investigate what tourniquet inflation pressures were being used by surgeons at this facility, to find out if they mimic a pre-determined value for every patient or whether they were individualized pressure settings based on patient systolic blood pressure. This project will then investigate if there were any differences in the recorded estimated blood loss (EBL), based on the tourniquet pressures used. This has led to the development of the following PICOT question, "In patients undergoing orthopedic surgery of the lower extremities, what is the effect of individualized tourniquet inflation pressures compared to facility standard inflation pressures on blood loss and other tourniquet related complications?"

This is to allow the conduction of a retrospective chart review, to compare the various tourniquet pressures that have been used for surgery of the lower extremities, and to determine their effects on blood loss and presence or absence of any tourniquet related complications.

Review of the Literature

A current literature review was conducted in October 2021. The search terms utilized in this literature search included tourniquet inflation pressures, lower extremity surgeries, blood loss and tourniquet related complications. The databases that were searched include CINAHL, PubMed and Google Scholar. Articles were included if they are primary research, systematic reviews, meta-analysis or randomized controlled trials (RCTs) which focused on the use of pneumatic tourniquets during lower extremity surgery, tourniquet inflation pressures, and effects on blood loss or tourniquet related complications in adult patients under general anesthesia. These articles must be most recent hence should have been published after the year 2015. A search conducted through PubMed database yielded a total of 128 articles initially. Ten (10) articles met the inclusion criteria and were included in the literature review. (See Appendix A). Four articles were randomized controlled trials, three were meta-analysis, two were systematic reviews while one article was primary research. Articles that did not meet the inclusion criteria were those that focused on tourniquet use in upper extremity surgery, tourniquet pain, tourniquet duration and associated complications, and articles that compared surgery with use of tourniquets versus surgery without tourniquets. Refer to Appendix C for Prisma diagram on literature search.

Pneumatic tourniquets are commonly used to reduce intraoperative bleeding during surgery of the extremities. Many surgeons prefer to perform extremity surgery such as total knee replacement with the aid of a pneumatic tourniquet. A tourniquet is an occlusive device which restricts blood flow to the distal extremity to help create a bloodless field during the surgical procedure. (Ahmed et al., 2020).

All ten studies, showed that tourniquet use can significantly decrease intraoperative blood loss, calculated blood loss, and the duration of surgery. (Ahmed et al., 2020, Cai et al., 2019,

Ding et al., 2019, Kim et al., 2019, Spruce, 2017). However, one systematic review noted that despite these benefits, complications can arise from the use of tourniquets, and these may include nerve injuries, pressure injuries, pain, tissue necrosis, compartment syndrome and chemical burns. Other serious injuries such as deep vein thrombosis, severe ischemic injuries, thermal damage to tissues, and rhabdomyolysis can also occur. (Spruce, 2017).

There are a wide variety of guidelines for deciding on the ideal tourniquet pressure during extremity surgery. However, three RCTs and one primary research showed that the practice of using fixed, high tourniquet pressures based on surgeon preference remains common. (Kim et al., 2019, Kukreja et al., 2018, Figueroa, 2021, Pinsornsak, 2021). All ten studies found that the use of high tourniquet pressures not based on limb occlusion pressure (LOP), lead to increased tourniquet related complications such as pain, excessive use of opioids, and prolonged PACU length of stay which further leads to increased healthcare costs. (Ahmed et al., 2020, Cai et al., 2019, Ding et al., 2019, Kukreja et al., 2018, Spruce, 2017). Two meta-analysis, four RCTs, one primary research and two systematic reviews confirmed that higher tourniquet pressures cause ischemia which has negative effects, such as the appearance of edema, stiffness, increased risk of deep vein thrombosis, wound problems, dysesthesia, a decreased range of motion, and nerve injuries resulting from excessive compression from the tourniquet. (Ahmed et al., 2020, Cai et al., 2019, Ding et al., 2019, Figueroa, 2021, Mateu et al., 2021, Pinsornsak, 2021).

According to three RCTs and one meta-analysis, while some surgeons as a matter of personal preference use a uniform tourniquet inflation pressure (UTIP) regardless of the patient, others use personalized tourniquet inflation pressures (PTIP) based on the specific patient's systolic blood pressure or the limb occlusion pressure. This is due to the fact that there exists no consensus regarding the optimal mode of inflating tourniquets during lower extremity surgeries.

(Kim et al., 2019, Figueroa, 2021, Pinsornsak, 2021, Sun et al., 2022). Despite the absence of a consensus regarding which pressures to inflate tourniquets, nine out of the ten studies clearly stated that the PTIP provides a similar bloodless surgical field compared with the conventional UTIP while minimizing deleterious effects and complications (Ahmed et al., 2020, Cai et al., 2019, Ding et al., 2019, Kukreja et al., 2018, Spruce, 2017, Sun et al., 2022).

One meta-analysis and two RCTs found no significant difference in terms of intraoperative blood loss (P = .48), and (100% vs. 99%, p = 1.000) between the use of PTIP and the UTIP. (Kim et al., 2019, Sun et al., 2022, Tuncali et al., 2018)). The literature overwhelmingly favors the use of PTIP in the sense that it provides less tourniquet pain intensity, optimal thigh circumference, lower rate of thigh ecchymosis, lower rate of limb ischemia or nerve damage, and better initial recovery of knee flexion in cases of lower extremity surgery. (Cai et al., 2019, Ding et al., 2019, Kukreja et al., 2018, Sun et al., 2022).

Three RCTs and two systematic reviews further identified that patient populations such as those with osteoarthritis undergoing lower extremity surgeries benefit from PTIP since it provides a similar bloodless field as the UTIP but carries the added advantages of having a 20% lower rate of wound complications at discharge and a 24% lower rate of wound complications after two weeks when compared with the UTIP. (Figueroa, 2021, Mateu et al., 2021, Pinsornsak, 2021).

A special study conducted on the obese population however showed that compared to non-obese patients, the obese patients required higher tourniquet inflation pressures during total knee arthroplasty since they have a wider extremity circumference in conjunction with a higher systolic blood pressure profile. (Tuncali et al., 2016).

Finally, one study investigated the use of PTIP via the use of ultrasonic doppler for setting lower extremity tourniquet pressures during surgery which ensured great hemostatic effect, while providing optimal individual tourniquet pressure value for the patient. Meanwhile, it also effectively reduced the incidence of adverse reactions associated with tourniquet use and improved tourniquet safety. (Mu et al., 2018).

All ten studies affirmed support for the use of the PTIP as opposed to the UTIP. There had been comparable outcomes in terms of limiting blood loss and the provision of a bloodless field by both the PTIP and the UTIP. Juxtaposing these results with the tourniquet related complications that are markedly increased in the use of the UTIP compared to the PTIP, it becomes evident that the PTIP provides the better option in terms of overall patient outcomes.

Evidence Based Practice: Verification of Chosen Option

The use of pneumatic tourniquets during extremity surgery is very common and a relatively safe practice. The surgical team's proper assessment, knowledge of the patient history, indications, contraindications and risks of tourniquet use can help prevent undesirable outcomes for the patient. (Jensen et al., 2019).

According to the Association of peri-Operative Registered Nurses (AORN) guidelines for tourniquet use, it is imperative to confirm the intended tourniquet pressure setting during the time out, and before the tourniquet inflation. The tourniquet must be inflated to a minimum effective pressure as determined by the surgeon based on the patient's systolic blood pressure and limb circumference. (AORN, 2019). A review of current literature in relation to the use of pneumatic tourniquets showed that several studies favor the use of PTIP based on limb occlusion pressure or the patient’s systolic pressure. The literature overwhelmingly suggests that, PTIPs provide similar bloodless surgical field compared with the conventional UTIP while minimizing

deleterious effects and complications. (Ahmed et al., 2020, Cai et al., 2019, Ding et al., 2019, Kukreja et al., 2018, Mateu et al., 2021, Pinsornsak, Spruce, 2017, Sun et al., 2022). This DNP project seeks to evaluate the overall adherence to the personalized tourniquet inflation pressures at the project site and if this recommendation is serving the intended purpose of minimizing blood loss while reducing tourniquet related complications.

Theoretical (Conceptual) Framework

One significant concept in nursing that had been under consideration for many years is reflection. It is a concept introduced by Dewey in the year 1933. (Galutira, 2018). The Theory of Reflective Practice in Nursing is a middle-range theory which emphasizes the necessity of nurses to practice reflection in four domains. These four domains include; reflection-before-action, reflection-in-action, reflection-on-action, and reflection-beyond-action. This is to help advance nursing practice considerably. (Galutira, 2018). Reflective practice has been found to possess the ability to impact positive outcomes such as professional or personal development, improvement in quality of care, and improved outcomes of care. (Redmond, 2017). Because of its undisputable ability to promote continuous development, reflective practice is considered as a crucial part of professional practice. When reflection is employed as a process of discovering alternative types of nursing knowledge such as aesthetic, empirical, ethical and personal forms, this leads to change in practice. The Theory of Reflective Practice in Nursing comprises of five concepts. These include; reflection, promoting factors, clinical experience, outcomes and hindering factors. Refer to appendix B for a diagram demonstrating how these five concepts are interrelated. The four domains of the theory of reflective practice have been defined thus; Reflection-before-action emphasizes a provider's duty to reflect before engagement into clinical activity. Reflection-in-action comprises of active reflective thinking and moment to moment decision making during

the course of the clinical activity. Reflection-on-action comprises the retroactive critical analysis of the clinical situation to recreate incidents. Finally, reflection-beyond-action comprises of critical thinking of the decision making and claims incorporated into the descriptions of nurses' experiences with reference to clinical practice. (Galutira, 2018). Patient factors such as systolic blood pressure, body habitus and weight, as well as hemodynamic stability must be considered while deciding what tourniquet pressures to use for each patient. A retrospective chart review is a great example of reflection-beyond the action. This comprises of collection and review of data to help discover problems that may exist within clinical practice. When the "Theory of Reflective Practice in Nursing" is applied within this domain of anesthesia practice, it would encourage healthcare facilities to adopt new evidence-based strategies that support the use of patient centered tourniquet pressures based on systolic blood pressures instead of a generalized approach based on facility protocols or surgeon preference.

Project Goals, Objectives and Expected Outcomes.

This project was designed with the main objectives of investigating pneumatic tourniquet pressures that were being used for patients undergoing orthopedic surgeries of the extremities in comparison with their average systolic blood pressures and juxtaposing that with the estimated blood loss (EBL) reported. Since the main reasons for using pneumatic tourniquets for extremity surgery are to minimize blood loss through artery occlusion and also provide a bloodless field for the surgeon, it is imperative to use the minimum pressure that is patient specific to achieve these goals. The objectives of this project are therefore listed below:

1. To review the medical records of at least 60 patients that had undergone lower extremity surgeries that required the use of tourniquets by March 2022.

2. Identify and record what the pre-tourniquet inflation systolic blood pressures of these patients were by March 2022.
3. Identify and record the tourniquet inflation pressures used for surgical procedures on these patients by March 2022.
4. Identify and record the EBL reported postoperatively by March 2022
5. Identify if tourniquet inflation pressures used were based on standard facility protocols or if they were tailored to patient specific needs based on their systolic blood pressures by April 2022.
6. Identify and record whether there were any significant differences in EBL between use of higher tourniquet inflation pressures based on standard facility protocols, and patient centered tourniquet pressures based on their systolic blood pressures by August 2022.

The expected outcome is to determine if higher tourniquet pressures based on facility protocols directly relate to less estimated blood loss and better creation of a bloodless field

Project Design

This DNP project is designed to use a retrospective chart review to obtain data that has previously been recorded. This project has therefore employed a quantitative descriptive method to assess adherence to, and utilization of patient centered tourniquet inflation pressures at this project site, and whether the aims of minimizing blood loss while reducing tourniquet related complications were being met. The project used a retrospective convenient sample of adult patients who underwent surgical intervention of the lower extremity requiring the use of pneumatic tourniquets during the first three months of the year 2022. The project aimed to reach a sample size of at least 60 patients. The actual sample size achieved was 75 patients. During review of the patient charts, inclusion of patients in the project sample were determined by

identifying patients who had lower extremity surgeries with documented tourniquet pressures and documented estimated blood losses. Additional data collected comprised of any related complications, patient demographic information such as age, gender, BMI, surgical procedure and ASA physical status.

Project Site and Population

The implementation of this DNP project was at a Midwestern Hospital in the United States of America. This non-profit organization is a level III Trauma Center with magnet designation. It is located in a predominantly white community and has 191 patient beds. (IU Health 2019).

The retrospective chart review has been conducted on adult patients of 18 years or older who underwent lower extremity surgery with the use of pneumatic tourniquets during the stipulated time frame for this project. Children or individuals 17 years of age or younger were excluded, and adults 18 years of age or older who received upper extremity surgeries or lower extremity surgeries without the use of tourniquets were all excluded.

Project site Strengths, Weaknesses, Opportunities and Threats (SWOT) Analysis

Strengths

This healthcare facility has an Electronic Medical Record (EMR) which facilitated a retrospective chart review.

It is standard practice at this facility to document time of pneumatic tourniquet inflation, tourniquet pressure and time of tourniquet deflation hence data was readily available.

This project does not require new experimentation with medications or procedures hence comes with a high level of safety for the subjects which facilitated the approval from the various Internal Review Boards (IRBs).

No significant financial investments were required for this study since it involved the retrospective review of anesthesia records.

Weaknesses

Blood loss is usually estimated hence may not be accurately reported and recorded. There has not been adequate availability of data for both topics of comparison because most physicians adhered to the facility protocol of tourniquet inflation pressures as opposed to patient centered pressures based on systolic blood pressure. The success of this project depends on adequate data for both PTIP and UTIP for comparison in order to ensure a fair comparative study.

The chart review required a significant time input to unearth all necessary data for this comparative study.

Opportunities

This healthcare facility is a busy one that sees a great number of orthopedic surgeries of the extremities yearly, hence, able to produce the necessary data for this study.

Education and EBP is one of the priorities of this facility hence provided a great support for the project ideas with the necessary guidance.

The facility mentor for this project was highly motivated about the prospects of this project and helped in any way possible to ensure a successful study.

Threats

It is unclear as to how long an anesthesia record remains accessible post patient discharge, hence, some charts may not be accessible for review purposes.

Physician preference to the use of tourniquet inflation pressures may significantly influence which type of data are available and if data may be evenly acquired for both topics of comparison.

Previous anesthesia records may not be readily accessible if there has been a recent shift in methods of documentation from paper-based charting to electronic medical records. See Appendix E. SWOT analysis.

Methods

The main intention of this project is to identify a gap in clinical practice and the extent to which evidence-based practice guidelines on tourniquet inflation pressures were being implemented. A retrospective chart review has been conducted at the chosen facility. A project mentor at the facility has gladly agreed and helped facilitate access to Electronic Health records and also provided guidance and direction when needed. An application for exemption was obtained from the Institutional Review Board (IRB) of Marian University before the commencement of data collection since this project involves data collection on human subjects. The retrospective chart review began once this exception was obtained. There was no need for an informed consent since only data that has previously been recorded have been reviewed and utilized. Charts were reviewed systematically beginning with surgical interventions involving the study group from January 1, 2022 through March 31, 2022. Adult patients who had lower extremity surgeries involving the use of tourniquets within this time frame were identified and data was collected in form of tourniquet inflation pressures, estimated blood loss, tourniquet related complications, surgical procedure, gender, BMI and age. This data was analyzed to determine the number of patients whose tourniquet inflation pressures were based on the PTIP method based on the AORN's guidelines versus the number of patients whose tourniquet

inflation pressures were based on the UTIP method. The estimated blood losses were then compared between the two groups, and any tourniquet related complications reported were also compared. These data were analyzed and recommendations made regarding the use of PTIP versus the UTIP.

Measurement Instrument

Patient EHRs were the source of all data collected for this project. The obtained data was placed into a Microsoft Excel spreadsheet and analyzed. The systolic blood pressure of the patient and the pressure to which tourniquet was inflated were recorded to determine if the tourniquet inflation pressure was based on PTIP which is 100mmHG above systolic blood pressure or based on conventional UTIP of 300mmHG-400mmHG regardless of patient. Other patient variables such as weight, age, gender was collected and analyzed to determine if any of these variables has an impact on the results of estimated blood losses or tourniquet related complications. Other data that was collected include the types and location of the lower extremity surgery to determine if these played a role in the amount of estimated blood loss. Due to the project being a retrospective chart review, the validity and reliability of measurement devices cannot be determined. Estimated blood loss is usually based on surgeons' judgement or the counting and weighing of sponges used during the surgical procedure. Since all these values are estimates, it would be difficult to determine their accuracy, hence the tendency of overestimation or underestimation greatly exists.

Data Collection Procedures

The data for this DNP project was systematically collected and manually recorded by conducting a retrospective chart review through access to patient EHRs. The facility mentor for this project facilitated access to the patient EHRs for this chart review to be conducted. Charts

were reviewed for the period of January 1, 2022 through March 31, 2022 for patients18 years of age and older, who had lower extremity surgical procedures requiring to use of pneumatic tourniquets. This chart review was completed in April 2022. The acquired data was entered into a Microsoft Excel spreadsheet without any patient identifiable information. This data was then saved withing the Marian University's password protected One Drive cloud. The surgical schedule for the period spanning January 1, 2022 through March 31, 2022 was identified and scrutinized for surgeries of adults over the age of 18 receiving lower extremity surgeries. The anesthesia records of these patients were then reviewed to determine if pneumatic tourniquets were used during the surgical procedure. The anesthesia record is further scrutinized to determine what systolic blood pressures were documented prior to the inflation of tourniquets, and the pressures to which the tourniquets have been inflated. Estimated blood losses documented at the end of surgical intervention was also recorded. Other information such as ASA physical status, gender, age and weight was collected once patient meets all the above criteria. Accessing EHRs of surgical patients less than 18 years of age or patients who received upper extremity surgeries, any other surgery that is not orthopedic, or lower extremity surgeries without the use of pneumatic tourniquets was avoided.

Data Analysis

The main aim of this project is to identify what systolic blood pressures were recorded prior to tourniquet inflation and what tourniquet inflation pressures were being utilized for surgeries of the lower extremities at this facility and juxtapose that with the documented EBL. This will help determine if individualized tourniquet pressures or universal tourniquet pressures were being used and if there were any differences in EBL. Hence, data collected were placed into an excel spreadsheet and analyzed to determine the Mean, Median and Modes of continuous

variables. Analyzing data in Microsoft Excel involved descriptive statistics. Counting was used to measure variables that are nominal such as, ASA physical status and gender. Mean, median and range was calculated for continuous variables such as age, tourniquet pressure and estimated blood loss via Microsoft Excel. The analyzed data was then scrutinized to determine what the facility protocol for tourniquet inflation was, and whether these protocols follow the PTIP or the UTIP methods of choosing tourniquet inflation pressures.

Results

The EMRs of 75 adult patients who underwent lower extremity surgery during the period of January 1, 2022 through March 31, 2022 were reviewed to determine if tourniquet inflation pressures were based on PTIP or UTIP. Overall, four different tourniquet inflation pressures were recorded at this facility for surgeries of the lower extremities on the 75 patients included in this study. These are; 250mmHg, 275mmHg, 300mmHg, and 350mmHg. Tourniquets were inflated to a pressure of 275mmHG on 57 patients, (76% of the sample size). This is regardless of their systolic blood pressures (SBP). Of the 57patients whose tourniquets were inflated to 275mmHg, 24 patients underwent total knee arthroplasty surgeries, 18 patients underwent knee arthroscopies, 9 patients underwent ankle fracture repair, and 6 patients underwent lower extremity I&D. Also, on these 57 patients, the highest SBP recorded for this group prior to tourniquet inflation was 168mmHg, while the lowest SBP recorded prior to tourniquet inflation was 103mmHg. Tourniquets were inflated to 250mmHg on 10 patients, (13.3% of the sample size). Of these 10 patients, 6 underwent ankle ORIF, and 4 underwent foot and toe I&Ds. The highest SBP recorded prior to tourniquet inflation for this group was 160mmHg and the lowest SBP recorded prior to tourniquet inflation was 96mmHg. Tourniquets were inflated to 300mmHg on 7 patients, (9.3% of the sample size). Of these 7 patients, 5 of them underwent total knee

arthroplasties while 2 patients underwent knee arthroscopy procedures. The highest SBP recorded for this group prior to tourniquet inflation was 153mmHg, and the lowest SBP recorded was 97mmHg. Tourniquet was inflated to 350mmHg for one patient (1.3%). This patient underwent a foot and toe I&D surgery, and had a systolic blood pressure of 119mmHg prior to tourniquet inflation. See Appendix F for pie chart representation of tourniquet pressures used. Of all 75 patients included in the study. The mean SBP recorded prior to tourniquet inflation was 133mmHg, the median SBP was 133mmHg, and the modal SBP was 134mmHg. The mean tourniquet inflation pressure was 275mmHg, the median was 275mmHg, and the mode was 275mmHg. The mean age for sample size was 58 years old, the median age was 61 and the modal age was 66. The oldest age recorded was 86 and the youngest age was 18.

Estimated blood losses (EBLs) were documented for all 75 patients. These range from a low of 5mL to a high of 250mL. Of the 75 patients in this study, the EBLs of 45 (60%) fell below 50mL. The EBLs of 18 patients (24%) fell between 51-100mL. The EBLs of 8 patients (10.6%) fell between 101-150mL. Also, the EBLs of 2patients (2.6%) fell between 151-200mL, while the EBLs of another 2 patients (2.6%) fell between 201-250mL. See Appendix G for a bar chart representation of EBLs. In general, the mean EBL recorded was 60.6mL, the median EBL was 50mL, and the modal EBL was 5mL.

Discussion/Interpretation

The results from this DNP project revealed that despite new evidence suggesting the use of PTIP for better patient outcomes, some providers still utilize the UTIP for inflating pneumatic tourniquets. This statement is true regarding this facility because, despite the diversity in systolic blood pressures recorded prior to tourniquet inflation, 76% of tourniquets were inflated to a

UTIP of 275mmHg. This was regardless of patient systolic blood pressures ranging from a low of 103mmHg to a high of 168mmHg. Despite the use of this UTIP however, it is worth noting that this UTIP has been chosen very carefully to mimic the mean tourniquet inflation pressure of most patients if a PTIP were to be calculated for all of them. This is because, according to the method of calculating PTIP proposed by Naglehout and Elisha (2018), which is based on twice the patient's SBP, then the PTIP tourniquet pressure for the highest recorded SBP of 168mmHg in the 275mmHG tourniquet pressure group would have been 336mmHg. And the PTIP tourniquet pressure for the lowest SBP of 103mmHg in this group would have been 206mmHg. This means that the tourniquet inflation pressure 275mmHg fell short by 61mmHg for the patient with SBP of 168mmHg, and was too high by 69mmHg for the patient with SBP of 103mmHg. However, considering Naglehout and Elisha recommends that the tourniquet should be inflated to 300mmHg if twice the patient's SBP is less than this value, it means the ideal PTIP for the patient with SBP of 103mmHg should be set at 300mmHg. Hence, instead of viewing the UTIP of 275mmHg used on this patient as too high by 69mmHg, it is actually too low by 25mmHg. Also, taking all 75patients in the study into account, the mean SBP recorded was 133mmHg. A calculated PTIP for these patients based on the mean would therefore be 266mmHg. And since this fell below the 300mmHg tourniquet inflation pressure recommended by Naglehout and Elisha for lower extremity surgeries, it means the tourniquets should have been inflated to 300mmHg on most of these patients. Since the goal of the PTIP is to use the minimum pressure possible for limb occlusion which can minimize blood loss, provide a bloodless surgical field while minimizing tourniquet related complications, the choice of the 275mmHg UTIP at this facility seems to be the safest and best practice for these patients. The findings of this project demonstrated that these goals of PTIP use have been achieved. This is because, the recorded

EBLs of 63 patients representing 84% of the Sample size fell below 100mL while 60% fell below 50mL. Also, as long as these same conditions for tourniquet use are met, the 10 patients whose tourniquets were inflated to 250mmHg received an even safer tourniquet inflation pressures which minimizes most complications of tourniquet use. The one patient whose tourniquet was inflated to a pressure of 350mmHg while having a SBP of 119mmHg prior to tourniquet inflation for a foot and toe I&D surgery, is a major outlier whose peculiar case could not be investigated beyond the scope of this study. It is unclear if this patient was taking any medications that placed him at a higher risk of bleeding which warranted a higher-than-normal tourniquet inflation pressure. Despite the higher pressure, no tourniquet related complications such as those enumerated throughout this study have been documented on this patient.

Cost-Benefit Analysis/Budget

The implementation of this DNP project did not incur any costs to the facility where the project was implemented. Practicum DNP student hours were utilized by the student to complete the implementation, analysis, and evaluation of this DNP project. However, if this project were to be an initiative of the organization where the project took place, cost of implementation by the organization would be the wages or salary of the person who completes the retrospective chart review.

Timeline

This DNP project is scheduled to be completed within a total of one calendar year. The project was initiated in August 2021, with the goal of completion by August 2022. (See GANTT chart, Appendix D. However, if this project had to be delayed for a few weeks or months due to any external or unforeseen circumstances, there is always room to adjust these timelines to accommodate such changes.

Ethical Considerations/Protection of Human Subjects

The main objective of this DNP project was to evaluate the necessity for practice changes to improve patient safety and optimize patient outcomes during surgical interventions requiring the use of pneumatic tourniquets. Prior to initiating the implementation phase of this project, an exemption was granted by the Institutional Review Board at Marian University on April 2022. No collection of any patient identifying information was made throughout the duration of this project. All the Health Insurance Portability and Accountability Act (HIPAA), standards were strictly maintained during this project. All values of Marian University, especially the value of maintaining the dignity of the individual were upheld during the implementation of this project through respect for the individual and by keeping patient information private.

Conclusion

During surgical interventions of upper or lower extremities, one of the methods in which blood loss can be decreased is through application of the pneumatic tourniquet. A bloodless field provides important advantages for the surgeon, and the pneumatic tourniquets provide a relatively good bloodless field to minimize intraoperative blood loss. (Naglehout & Elisha, 2018).

One significant safety measure for preventing tourniquet related complications is ensuring that only minimally effective pressure is used for occluding blood flow to the extremity. For this reason, there is the need for an individualized tourniquet inflation pressure tailored to each patient based on systolic blood pressure, limb circumference and limb occlusion pressure. (Spruce, 2017).

In actual practice however, and for that matter at this facility, some surgeons have requested tourniquet pressures much higher than these thresholds. Surgeons commonly inflate

lower extremity tourniquets to a standard pressure of 350mmHg. (Kim & Kim, 2018). This DNP project was therefore designed to conduct a retrospective chart review to identify the use of patient centered tourniquet inflation pressures compared to universal tourniquet inflation pressures and juxtapose the values with the recorded estimated blood loss (EBL). This is to help identify if there is any difference in the amount of recorded EBL or if both methods provide similar outcomes with regards to the amount of EBL.

The retrospective chart review found that a total of 75 patients received lower extremity surgery with pneumatic tourniquet use at this facility between January 2022 through March 2022. Of the 75 patients, the tourniquet inflation pressure was set at 275mmHg for 57 patients (76%). Therefore, the facility UTIP is identified as 275mmHg. This Tourniquet Inflation pressure is lower when compared with the recommendation of Naglehout and Elisha which indicated that tourniquets for lower extremity surgeries should be set at twice the patient's SBP or 300mmHg whichever is greater. Despite a lower UTIP choice, EBLs of 63 patients 84% fell below 100mL, while 60% fell below 50mL. This lower UTIP therefore served the purpose of minimizing intraoperative blood loss and providing a bloodless surgical field for the surgeon while minimizing tourniquet related complications. This is because, no complication was documented with regards to the use of pneumatic tourniquets in these patients.

Although the literature is overwhelmingly in favor of using the PTIP, an excellent UTIP choice by this facility which is primarily lower than most PTIPs served the same purpose of using the minimum pressure possible for artery occlusion to achieve a bloodless field, decrease blood loss and greatly minimize tourniquet related complications.

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Appendix A

Citation	Research Design & Level of Evidence	Population / Sample size n=x	Major Variables	Instruments / Data collection	Results
Ahmed, I., Chawla, A., Underwood, M., Price, A. J., Metcalfe, A., Hutchinson, C., Warwick, J., Seers, K., Parsons, H., & Wall, P. D. (2020). Tourniquet use for knee replacement surgery. *The Cochrane database of systematic reviews*, *12*(12), CD012874.	Systematic review Level I	41 RCTs	Knee replacement with tourniquet use, estimated blood loss, pain, thromboembolism	Certainty of evidence was assessed using the GRADE approach	Knee replacement with tourniquet is associated with increased risk of serious adverse events and post-op pain. No significant differences in estimated blood loss between higher tourniquet pressure use and personalized tourniquet pressures.
Cai, D. F., Fan, Q. H., Zhong, H. H., Peng, S., & Song, H. (2019). The effects of tourniquet use on blood loss in primary total knee arthroplasty for patients with osteoarthritis: a meta-analysis. *Journal of orthopaedic surgery and research*, *14*(1), 348. https://doi.org/10.1186/s13018-019-1422-4	Meta-analysis Level I	11 RCTs	Tourniquet pressures, calculated blood loss, risk of DVT, operation time	The Cochrane collaboration's tool	Tourniquet use significantly decreased intraoperative blood loss ($P < 0.002$), calculated blood loss ($P < 0.002$) and time of operation ($P < 0.002$). No significant difference was found between higher tourniquet pressures and personalized tourniquet pressures ($P > 0.05$)
Ding, L., Ding, C. Y., Wang, Y. L., Wang, M. L., Qian, X. H., Huang, L., Xie, X. E., & Ji, H. Z. (2019). Application effect of pneumatic tourniquet with individualized pressure setting in orthopedic surgery of extremities: A meta-analysis. *Journal of advanced nursing*, *75*(12), 3424–3433.	Meta-analysis Level I	9 RCTs	Individualized pressure setting, tourniquet inflation pressure, estimated blood loss, orthopedic surgery	The Cochrane collaboration's tool for quality evaluation	An individualized inflation pressure is recommended when using the tourniquet in orthopedic surgery. Only minimum effective pressure is needed and can be determined by accessing the systolic pressure and limb circumference of the patient.

Figueroa D. (2021). In TKA, Lower versus higher tourniquet inflation pressures reduced postoperative pain at the tourniquet inflation site and surgical site at 24 and 48 hours and 2 weeks. *The Journal of bone and joint surgery. American volume*, *103*(22), 2143. https://doi.org/10.2106/JBJS.21.01008	Randomized controlled trial Level II	150 patients	Tourniquet inflation pressures, estimated blood loss, postoperative pain	Knee society scoring scale, visual analog scale	Higher tourniquet inflation pressures increased wound complications at discharge 20% versus 4 percent with lower pressures. No significant difference between estimated blood losses in higher versus lower inflation pressures
Kim, T. K., Bamne, A. B., Sim, J. A., Park, J. H., & Na, Y. G. (2019). Is lower tourniquet pressure during total knee arthroplasty effective? A prospective randomized controlled trial. *BMC musculoskeletal disorders*, *20*(1), 275. https://doi.org/10.1186/s12891-019-2636-7	Randomized controlled trial Level II	160 knee surgeries	Lower versus higher tourniquet pressures, estimated blood loss, quality of surgical field	Computer generated randomization table, visual analog scale, 5-point Likert scale.	Surgical field has comparable quality in both groups. (100% versus 99%). (P=1). There was no difference in hemoglobin drop, estimated blood loss and drained blood volume
Kukreja, P., Lehtonen, E., Pinto, M. C., Patel, H. A., McKissack, H. M., & Shah, A. (2018). Postoperative tourniquet pain in patients undergoing foot and ankle surgery. *Cureus*, *10*(12), e3678. https://doi.org/10.7759/cureus.3678	Retrospective cohort study Level IV	128 patients	Higher versus lower tourniquet pressure, intraoperative blood loss, incidence of tourniquet pain	Blood pressure measurement with cuff, Linear regression analysis	Prolonged tourniquet times at higher pressures as opposed to limb occlusion pressures (LOP) leads to longer length of PACU stay and increased opioid use. Safety margin of tourniquets are improved by basing pressure on limb occlusion pressure of patient
Mu, J., Liu, D., Ji, D., Li, B., Li, Z., Zhang, F., & Lineaweaver, W. C. (2018). Determination of pneumatic tourniquet pressure of lower limb by ultrasonic doppler. *Annals of plastic surgery*, *80*(3), 290–292. https://doi.org/10.1097/SAP.0000000000001247	Clinical controlled trial Level III	96 patients	Surgeon choice tourniquet pressure versus doppler measured LOP, calculated blood loss, incidence of tourniquet	Measurement of LOP using ultrasonic doppler, Linear regression analysis	Lower tourniquet pressures based on LOP ensures similar hemostatic effects and provision of bloodless field, while reducing the incidence of adverse reactions to tourniquet use and improve safety.

			complications, pain.		
Pinsornsak, P., Pinitchanon, P., & Boontanapibul, K. (2021). Effect of different tourniquet pressure on postoperative pain and complications after total knee Arthroplasty: A Prospective, Randomized Controlled Trial. *The Journal of arthroplasty*, *36*(5), 1638–1644. https://doi.org/10.1016/j.arth.2020.12.049	Randomized controlled trial (RCT) Level II	450 patients	Higher versus lower tourniquet pressures, pain, blood loss, muscle damage, wound complication	Visual analog scale for pain, Knee society score.	Total blood loss showed no significant difference in the study groups. Similar results were noted in the quality of bloodless field. However, muscle damage, pain and wound complications were higher in the group with higher tourniquet pressures
Sun, C., Yang, X., Zhang, X., Ma, Q., Yu, P., Cai, X., & Zhou, Y. (2022). Personalized tourniquet pressure may be a better choice than uniform tourniquet pressure during total knee arthroplasty: A PRISMA-compliant systematic review and meta-analysis of randomized-controlled trials. *Medicine*, *101*(8), e28981. https://doi.org/10.1097/MD.0000000000028981	Meta-analysis Level I	13 RCTs	Uniform tourniquet inflation pressure, personalized tourniquet pressure, blood loss, pain, nerve damage	Visual analog scale	Personalized tourniquet pressures provide a similar bloodless surgical field when compared to the uniform tourniquet pressures and also provides less pain intensity, less rate of ecchymosis, compared to the uniform pressures.
Tuncali, B., Boya, H., Kayhan, Z., & Arac, S. (2018). Tourniquet pressure settings based on limb occlusion pressure determination or arterial occlusion pressure estimation in total knee arthroplasty? A prospective, randomized, double blind trial. *Acta orthopaedica et traumatologica turcica*, *52*(4), 256–260. https://doi.org/10.1016/j.aott.2018.04.001	Randomized controlled trial Level II	93 patients	Tourniquet pressure, limb occlusion pressure, effectiveness of tourniquets, blood loss, pain, nerve damage	Likert scale	Tourniquet pressures based on limb occlusion pressure provides a similar surgical field compared to surgeon determined higher pressures while minimizing complications such as nerve damage, ecchymosis, tourniquet pain.

Appendix B

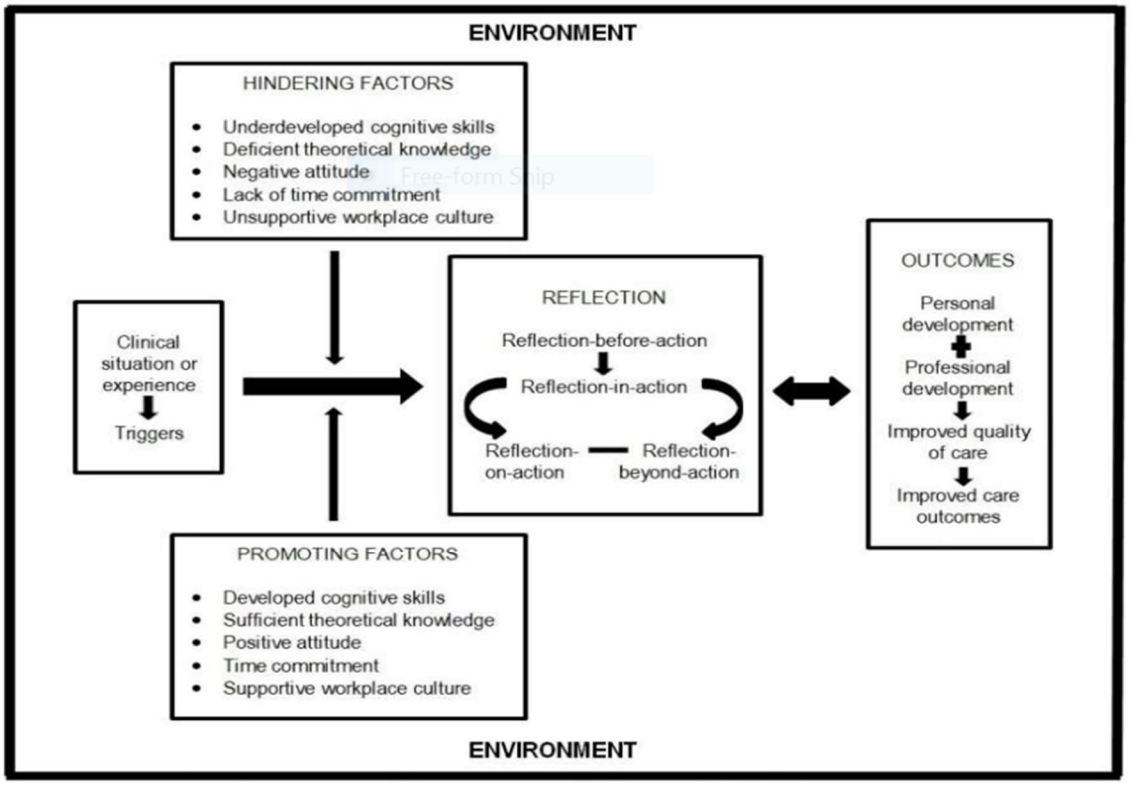
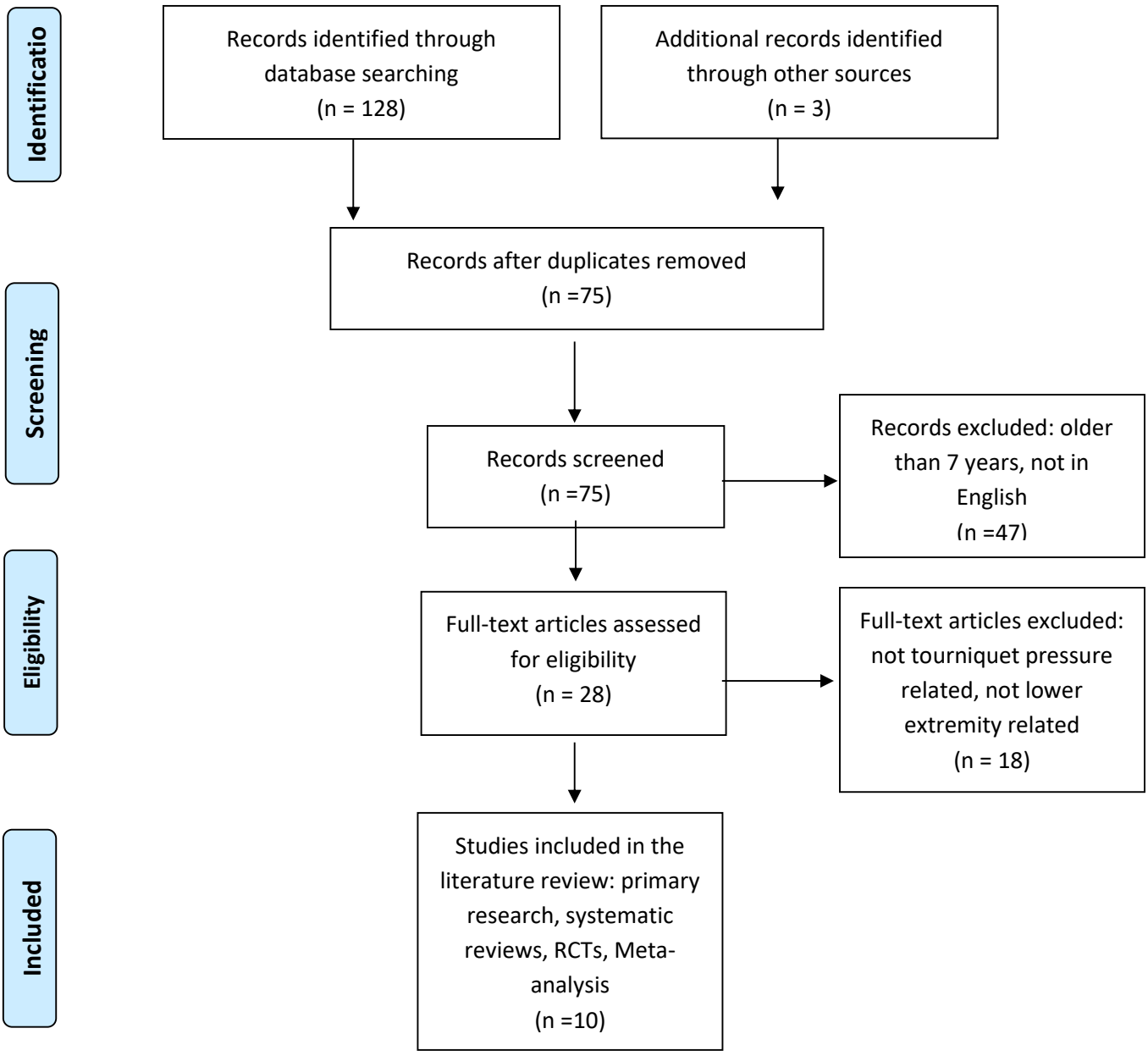


Figure 1. Conceptual Framework of the Theory of Reflective Practice in Nursing

Figure 1. The Theory of Reflective Practice in Nursing Conceptual Framework (Galutira, 2018)

Appendix C
PRISMA 2009 Flow Diagram

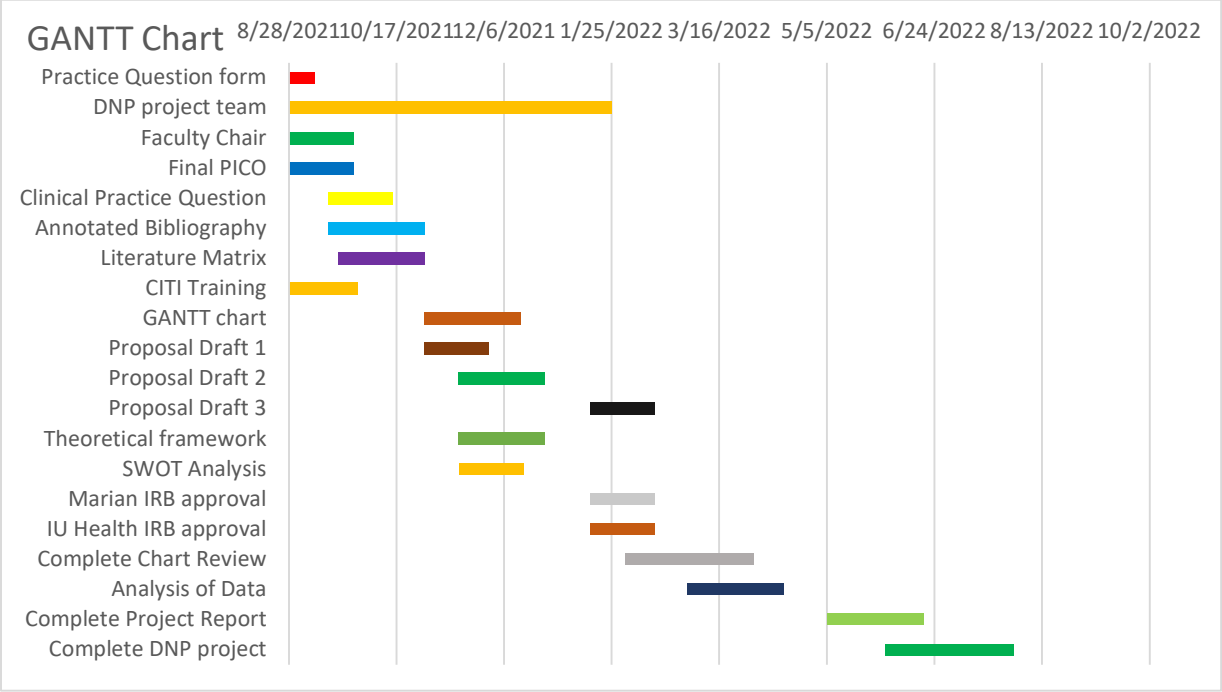


From: Moher D, Liberati A, Tetzlaff J, Altman DG, The PRISMA Group (2009). *P*referred *R*eporting *I*tems for *S*ystematic Reviews and *M*eta-*A*nalyses: The PRISMA Statement. PLoS Med 6(7): e1000097. doi:10.1371/journal.pmed1000097

For more information, visit www.prisma-statement.org.

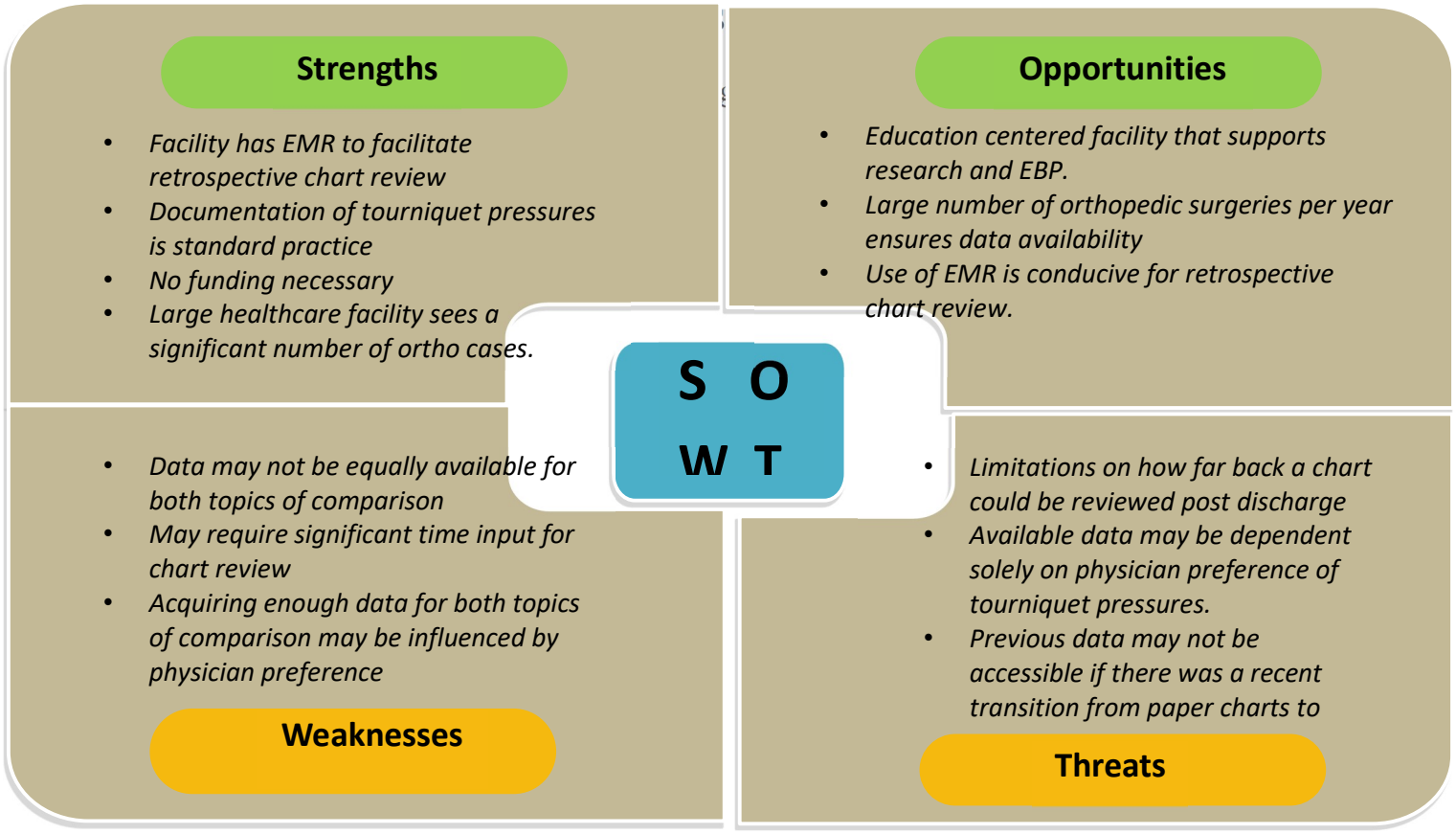
Appendix D

GANTT chart



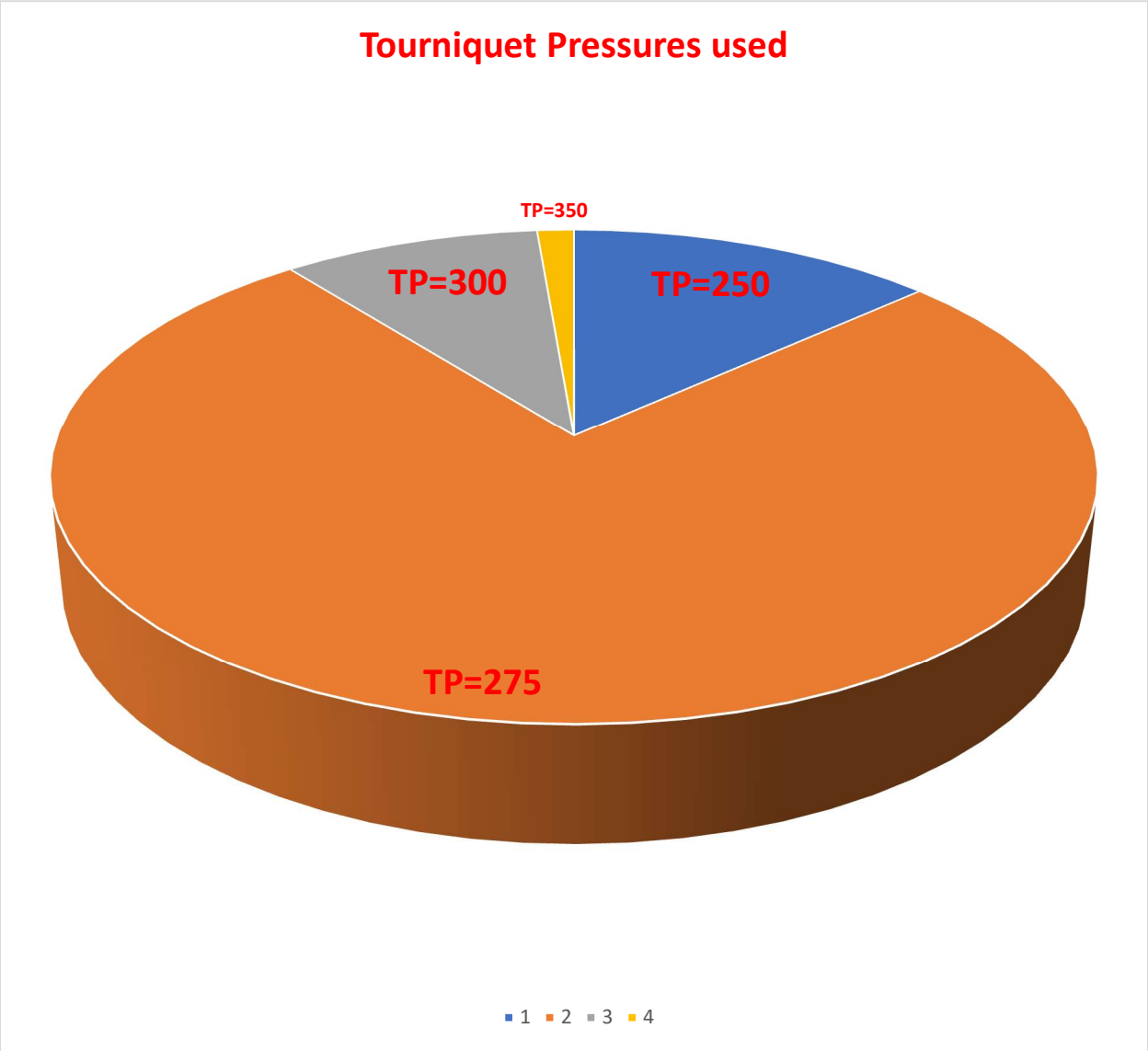
Appendix E

SWOT Analysis

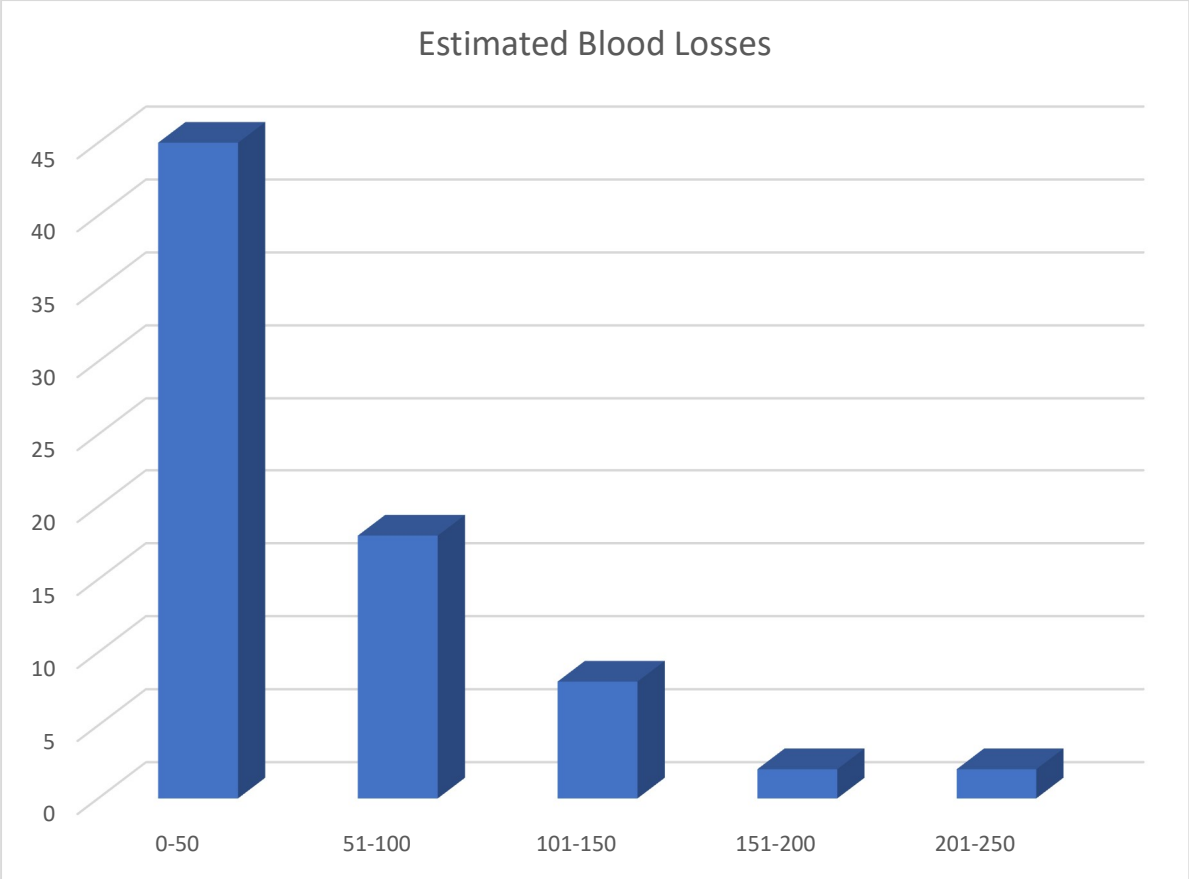


Appendix F

Pie Chart (Tourniquet Pressures)



Appendix G


Estimated Blood Losses
45
40
35
30
25
20
15
10
5
0
0-50
51-100
101-150
151-200
201-250