Hypovolemic Shock in Total Knee Arthroplasty

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ABSTRACT

Objective: Patients who receive total knee arthroplasty, which is a procedure that typically results in large amount of blood loss, have a higher probability of experiencing hypovolemic shock which can result in life threatening complications for the patient. Based on study and practice, the amount of blood loss can vary significantly. Currently, there are no other studies related to hypovolemic shock after total knee arthroplasty. The objective of this research is to study protective measures against hypovolemic shock after severe loss of blood which can occur after total knee artrhoplasty surgery and to ensure the safety of the patient post total knee arthroplasty surgery.

Methods: This is a retrospective study. Study subjects were patients who received total knee arthroplasty surgery at Jainad Narendra Hospital from October 1, 2007 through March 31, 2010. The total number of study subjects enrolled was 124 patients and 139 subjects. The study focused on the occurrence of hypovolemic shock after knee artrhoplasty surgery. Hypovolemic shock is a state of decreased blood volume characterized by a blood pressure lower than 80/60 mmHg and heart rate of over 100 beats per minute.

Results: Out of the 139 subjects, 20 subjects experienced hypovolemic shock after total knee arthroplasty surgery and 119 subjects did not. Differences in the amount of blood given to patients who experienced hypovolemic shock and those who did not experience hypovolemic shock did not indicate any statistical significance with a p-value <0.05. Differences in hematocrit levels pre-operation and two hours post-operation, surgical time, and amount of blood loss post-operation did not indicate any statistical significance with p-value < 0.05 when comparing patients who expe-rienced hypovolemic shock and those that did not after total knee arthroplasty surgery.

Conclusion: Total knee arthroplasty surgery can cause severe blood loss that can lead to hypovolemic shock, which can cause life threatening complications for the patient. Therefore, it is critical to maintain proper care and close observation for post-surgical patients who received the procedure 4 hours prior.

Keywords: Hypovolemic shock, total knee arthroplasty

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Currently, rising numbers of elderly populations have resulted in a constant increase in patients who are experiencing bone diseases such as osteophytes, osteoporosis, and osteoarthritis. Knee osteoarthritis is among the more common diseases of the elderly. Treatment can range from lifestyle changes, exercising, medication, and joint injections. If all other non-surgical treatment is ineffective, patients would usually have to undergo joint surgery. Among the different types of surgical procedures used for the knee, the most preferred procedure is to replace the total joint surfaces of the knee with plastic or metal components (total knee arthroplasty).[1]

Total knee arthroplasty is a very effective treatment and is usually performed on elderly patients with age-related diseases such as diabetes, hypertension, and patients with coronary heart disease that are on medication. Patients with age-related diseases have a higher likelihood of complications post-operation.[2] The most critical complication that can occur post-operation is blood loss since the procedure involves the cutting of bone as well as surrounding tissues in the knee joint. Based on study and practice, the amount of blood loss can vary significantly. Five hundred -1,000 ml of blood can be lost during the procedure and post-operation through surgical drains.[3-4] Twenty four percent -53% of patients require blood transfusions.[5-8] Severe blood loss without immediate transfusion of blood and vital fluids can result in hypovolemic shock.

Hypovolemic shock occurs when the body does not receive enough blood to function (inadequate tissue perfusion), which is usually due to severe blood or fluid loss. The level of blood flowing out of the heart is inadequate and causes an imbalance between the amount of oxygen flowing to the tissues and the amount of oxygen that the tissues need to function. Patients will experience

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approximately 30-40% drop in blood pressure.[9-10] Patients who receive total knee arthroplasty, which is a procedure that typically results in large amount of blood loss, have a higher probability of experiencing hypovolemic shock. Orthopaedic surgeons at at Jainad Narendra Hospital found that research into hypovolemic shock was crucial due to the high prevalence of hypovolemic shock among patients who undergo surgery at this hospital. Their study focused primarily on the factors that cause hypovolemic shock among patients who undergo total knee arthroplasty as well as measures to treat and prevent future cases. Currently, there are no other studies related to hypovolemic shock after total knee arthroplasty.

MATERIALS AND METHODS

This is a descriptive comparative study. The study subjects were patients who received total knee arthroplasty surgery at Jainad Narendra Hospital. All total knee arthroplasty surgeries were conducted by three surgeons from the Jainad Narendra Hospitals orthopaedic department. The surgeries were conducted from October 1, 2007 through to March 31, 2010. The total number of study subjects enrolled was 124 patients and 139 subjects where 23 were male and 116 were female. The average age of all subjects was 64.07 years with an age range between 47-78 years.

Selection criteria for selecting subjects were the following: patients who underwent primary total knee arthroplasty without requiring revision total knee arthroplasty, patients did not have any blood diseases, all patients had normal blood coagulation, all surgeries had to involve incisions on the anterior cruciate ligament (ACL) and posterior cruciate ligament (PCL), and surgeries required the use of bone cement to anchor the artificial joint to the bone. The drains were not clamped after all operations and were removed after 48 hours. The criteria for blood transfusion in the patients with and without hypovolemic shock were hematocrit less than 30%.

Data was gathered from patient medical records. Information taken included gender, age, history of underlying diseases, if patients were evaluated for anesthesia using the American Society of Anesthesiologist standard prior to surgery, the patients levels of hematocrit pre and post-operation, amount of surgical time, amount of blood loss post-operation through surgical drain, whether blood transfusions were required, patients heart rate and blood pressure post-operation, and length of time that the patient was in a state of hypovolemic shock post-operation. The study defined hypovolemic shock as when a patients blood pressure drops below 80/60 mmHg and a heart rate increase of over 100 beats per minute.[11] This research was approved by the Jainad Narendra Hospitals Ethical Association.

Statistical analysis

The researchers analysis was conducted using Statistical Package for the Social Sciences (SPSS). Statistical significance value was set at .05. Analysis details are as follows:

1. Distribute the frequency of all data in percentage values.
2. Determine the mean and standard deviation.
3. Comparison of the data for patients who experienced hypovolemic shock and those who did not using statistical Chi-Square test and Independent t-test.

RESULTS

Data gathered from patient medical records indicated that a total of 142 subjects received total knee arthroplasty during the time period from October 1, 2007 through March 31, 2010. Out of that total, 139 subjects were used in the study which included 23 males and 116 females with an average age of 64.07 years (range of 47-76 years) and an average body weight of 61.90 kilograms (range of 40-87 kilograms). Seventy six participants had underlying diseases which included 70 participants with diabetes, 18 with hypertension, and 12 who had both diabetes and hypertension. All patients were evaluated for anesthesia using the American Society of Anesthesiologist (ASA) standard prior to surgery. Among the subjects, 4 were classified as ASA class 1, 110 were classified as ASA class 2, and 25 were classified as ASA class 3. (Table 1)

Among the 20 subjects who experienced a state of hypovolemic shock post-operation, 5 were male and 15 were female. All had an average age of 64.70 years (range between 51-76 years) and an average body weight of 60.40 kilograms (range of 45-79 kilograms). ASA class separations among this group were as follows: 1 subject was classified as ASA class 1, 16 subjects were classified as ASA class 2, and 3 subjects were classified as ASA class 3. As for underlying diseases, 9 subjects had diabetes, 2 subjects had hypertension, 2 subjects suffered from rheumatoid arthritis, 3 subjects had hypercholesterolemia, and 1 subject suffered from ischemic heart disease.

Among the 119 subjects that did not experience hypovolemic shock, 18 subjects were male and 101 were female. The average age in this group was 64.18 years (range from 47-78 years and the average body weight was 62.15 kilograms (range of 40-87 kilograms). ASA class separations were distributed as follows: 3 subjects

TABLE 1. Sample group characteristics defined by number of subjects, gender, ASA class, age and body weight.

Sample group description	Hypovolemic shock	Without hypovolemic shock	P-value (t-test)	Total
Number of subjects	20	119	-	139
Gender			0.272	
Male	5	18		23
Female	15	101		116
ASA			0.785	
ASA class 1	1	3		4
ASA class 2	16	94		110
ASA class 3	3	22		25
Age (Mean ± SD)	64.70 ± 8.97	64.13 ± 6.86	0.790	64.07 ± 6.82
Body weight (Mean ± SD)	60.40 ± 8.81	62.15 ± 9.63	0.448	61.90 ± 9.50

TABLE 2. Data comparison between patients with hypovolemic shock and patients without hypovolemic shock.

Data Type	Patients with Hypovolemic shock (mean ± SD)	Patients without hypovolemic shock (mean ± SD)	P-value (t-test)	Total (mean ± SD)
Hematocrit levels Pre-Op (%)	37.22 ± 3.15	36.34 ± 3.84	0.274	36.46 ± 3.75
Hematocrit levels 2 hours Post-Op (%)	33.50 ± 4.36	33.01 ± 3.69	0.640	33.08 ± 3.78
Operation time (minutes)	83.90 ± 25.62	93.75 ± 37.46	0.149	92.33 ± 36.09
Amount of blood loss (ml)	1,227.50 ± 457.41	1,018.86 ± 512.41	0.074	1,048.88 ± 508.65
Amount of blood transfused (ml)	740 ± 472.84	400 ± 379.12	0.006	448.92 ± 409.91

were classified as ASA class 1, 94 subjects were classified as ASA class 2, and 22 subjects were classified as ASA class 3. As for underlying diseases, 61 subjects had diabetes, 16 subjects had hypertension, 1 subject suffered from rheumatoid arthritis, 11 had hypercholesterolemia, and 2 subjects suffered from ischemic heart disease.

Statistical analysis conducted from data regarding ASA classifications, age and body weight indicated that there was no statistical significance among the two groups with p-value <0.05.

Hematocrit levels of all patients pre-operation averaged at 36.46% and an average of 33.08% two hours post-operation. The average operation time was 92.33 minutes. The average amount of blood loss post-operation was 1,048.88 ml. Ninety nine subjects received blood transfusions with an average amount of blood transfused of 448.92 ml., and 40 subjects did not require blood transfusions.

Among the group of patients who experienced a state of hypovolemic shock, hematocrit levels were measured at 37.22% pre-operation and 33.50% two hours post-operation. The average operation time was 83.90 minutes. The average amount of blood loss within this group was 1,227.50 ml. with 19 patients who required blood transfusions and 1 patient who did not receive a transfusion. The average blood transfused was 740 ml., among those that did require a transfusion.

Among the group of patients who did not experience any hypovolemic shock, hematocrit levels were measured at 36.34 pre-operation and 33.01% two hours post-operation. The average operation time was 93.75 minutes. The average amount of blood loss within this group was 1,018.86 ml., with 80 patients requiring blood transfusions and 39 patients who did not require a transfusion. The average blood transfused was 400 ml., among those that did require a transfusion.

The differences between the amount of blood transfused was found to have statistical significance with p-value <0.05 among the two groups of patients who did and who did not experience hypovolemic shock.

The differences between hematocrit levels pre and 2 hours post-operation as well as the amount of blood loss post-operation was found not to be statistically significant with p-value < 0.05 when compared among the two groups of patients who did and who did not experience hypovolemic shock. (Table 2)

Further analysis of the data indicated that among the 20 patients that experienced a state of hypovolemic shock, hematocrit levels were found to be 37.22% pre-operation and 31.44% at the onset of hypovolemic shock. The corresponding decrease in hematocrit levels was averaged at 6.18%. The amount of blood loss at the onset of hypovolemic shock was measured at 682 ml when compared to the total amount of average blood loss pre and post-operation which was 1227.50 ml. Additional data comparisons can be made between the amount of blood transfused for patients before hypovolemic shock which averaged at 100 ml and the total amount of blood transfused, which averaged at 740 ml. The average onset of acute hypovolemic shock was 428.25 minutes post-operation and the median was 240 minutes post-operation. The amount of average urine output after operation prior to hypovolemic shock was measured at 100.34 ml/hr. (Table 3)

DISCUSSIOIN

Total knee arthroplasty surgery is a major operation that results in a large amount of blood loss, which can lead to hypovolemic shock. There are many factors that can lead to severe blood loss during total knee arthroplasty surgery. Such factors may include surgical technique,[12] utilization of surgical drain,[13] technique in administering anesthesia,[14] position of the knee during surgery,[15] time of tourniquet utilization,[16] the utilization of clamps on the surgical drain,[17] and the utilization of cold compression dressing.[18] Hematocrit levels were significant in determining whether blood transfusions were required. The use of blood transfusions were not correlated with age, gender, body mass index, blood pressure, or a patients medical history of underlying diseases.[19]

TABLE 3. Data comparison among patients with hypovolemic shock.

Data type	Average value (Mean ± SD)
Hematocrit levels pre-operation (%)	37.61 ± 2.97
Hematocrit levels at onset of hypovolemic shock (%)	31.44 ± 4.61
Decrease in hematocrit levels at hypovolemic shock (%)	6.18 ± 4.25
Amount of blood loss at onset of hypovolemic shock (ml)	682 ± 269.96
Total amount of blood loss (ml)	1,227.50 ± 457.41
Amount of blood transfused prior to hypovolemic shock (ml)	100 ± 177.71
Total amount of blood transfused (ml)	740 ± 472.84
Average duration of acute hypovolemic shock (minutes)	428.25 ± 548.65
Average urine output after operation prior to hypovolemic shock (ml/hr)	100.34 ± 107.92

The research indicated that the amount of blood loss post-operation among patients who did not experience hypovolemic shock, averaged at 1,018.86 ml. in comparison to patients that did experience hypovolemic shock, which averaged at 1,227.50 ml. The difference in amount of blood loss between the two groups was found not to be statistically significant with a p-value <0.05. The average amount of blood loss at the onset of hypovolemic shock was found to be 682 ml. This value may be used as a benchmark to guard against the onset of hypovolemic shock meaning that if more than 682 ml. of blood was lost, serious consideration must be made towards initiating a blood transfusion.

A study conducted by Bernstein LH, et al, found that the amount of blood transfusions can be decreased if the amount of blood loss between the time during operation and post-operation, hemoglobin levels should be below 2 g/dl or hematocrit levels should be below 6%.[20] In comparison, this study found that at the onset of hypovolemic shock, reduction in hematocrit levels averaged at 6.17% which means that hematocrit levels falling by 6.17% could initiate the onset of hypovolemic shock. Therefore, 6.17% could be used as a benchmark to guard against the onset of hypovolemic shock.

The differences between the amount of blood transfused was found to have statistical significance with a p-value <0.05 among the two groups of patients who did and did not experience hypovolemic shock. The average amount of blood transfused for patients who experienced hypovolemic shock was 340 ml more than for patients who did not experience hypovolemic shock. Among those that did experience hypovolemic shock, the average amount of blood transfused was 740 ml per person, which if not transfused quickly could cause the patient to go into hypovolemic shock. Therefore, insufficient transfusion of blood and fluid could result in the onset of hypovolemic shock. Data taken from patients that did not experience hypovolemic shock indicated that on average 400 ml of blood was transfused per person. In comparison, patients that did experience hypovolemic shock received on average 740 ml of blood by transfusion per person. Based on the findings, to ensure the safety of each patient, at least 2 units of blood should be available during each surgery. Similarly, Caprano Ls research also found that on average 1.8-2.8 units of blood was transfused per patient during total knee arthroplasty surgery[21] while Helm AT suggested that an average of 1.1 units of blood per patient was transfused during total knee arthroplasty surgery.[4]

The average onset of acute hypovolemic shock was 428.25 minutes or 7 hours and 8 minutes post-operation with a range between 5-2, 545 minutes. This means that the onset of hypovolemic shock can occur post-operation anytime between 5 minutes post-operation up to 42 hours post-operation. Removing the maximum value (2,545 minutes) and minimum value (5 minutes), the average time before the onset of hypovolemic shock post-operation is found to be 334.17 minutes or 5 hours and 34 minutes with a range of 75-885 minutes (1 hour and 15 minutes to 14 hours and 45 minutes). The values can be used as a benchmark to ensure that patients are closely monitored for the first 15 hours post-operation and with stronger emphasis on the first 5-6 hours post-operation, because of the wide range of onset of acute hypovolemic shock. In this research, the median was more appropriate than the mean because of the wide range of time and the median was 240 minutes post-operation. These values can be used as a benchmark to ensure that patients are closely monitored for the first 4 hours post-operation.

Based on this research, it is apparent that monitoring the patients hemodynamic parameters between the time during operation and post-operation is paramount. Vital signs must be maintained at normal rates as much as possible. Fluids must be given to ensure proper blood flow to various organs of the body especially when utilizing bone cement or while removing a tourniquet to avoid hypovolemic shock.[2]

Currently, there is no definitive agreement to determine when the use of transfusions are necessary based on hematocrit levels for patients undergoing total knee arthroplasty. This research has found that if hematocrit levels drop no more than 6.17% or the amount of blood loss during and post-operation is no more than 682 ml, blood transfusions will not be required to avoid hypovolemic shock. However, the patients condition and symptoms must also be taken into account.

CONCLUSION

Total knee arthroplasty surgery is a major operation that results in a large amount of blood loss, which can lead to hypovolemic shock and can result in life threatening complications for the patient. Therefore, particular emphasis should be placed on having patients closely monitored for the first 4 hours post-operation. It is also important to observe the amount of blood loss during the operation as well as through surgical drains in post-operation. Blood and fluid transfusions can help to avoid any further complications from surgery and help patients return to normal life.

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