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Comparative Analysis of Direct And Gradual Torniquet Deflation on Blood Pressure Changes in Total Knee Arthroplasty Surgery Patients

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INFORMASI

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ABSTRACT

Objective: to analyze the differences in blood pressure reduction in TKA patients after direct and gradual tourniquet deflation.

Methods: Using the Quasy experiment, the population was TKA surgery patients in the Central Surgery Room at Dr. RSUD. Soedono, East Java Province in January – March 2024. Using Simple Random Sampling techniques, it was found that n=24 respondents were divided into intervention group n=12 and control group n=12. Data analysis used the independent T-test.

Results: There was no significant difference in pre-intervention systolic and diastolic blood pressure between the gradual and direct groups (p=0.055, p=0.451), there was no significant difference in post-intervention systolic blood pressure between the gradual and direct groups (p=0.578) and there was a significant difference diastolic blood pressure at post intervention between the gradual and immediate groups (p=0.032). The mean difference between pre and post systolic blood pressure in the gradual deflation group was 4.08 mmHg and Dyastole was 6.17 mmHg. Meanwhile, the difference in the mean value of pre and post Systole blood pressure in the direct deflation group was 19.31 mmHg and Dyastole was 10.55. The decrease in blood pressure in both systole and diastole in the gradual deflation group was smaller than in the immediate deflation group.

Conclusion: Gradual tourniquet deflation allows for a smaller risk of lowering blood pressure than directly so it can be considered as an alternative method of tourniquet deflation after TKA surgery.

INTRODUCTION

Total Knee Arthroplasty (TKA) is a surgical treatment aimed at improving mobility and quality of life for patients with advanced knee osteoarthritis. The prevalence of this procedure has increased substantially in the last decade and is expected to continue (Leurcharusmee et al. 2018). Many surgeons prefer to perform TKA surgery with tourniquet assistance. A tourniquet is an occlusive device that restricts distal blood flow to help create a bloodless field during the procedure. However, tourniquet use increases the risk of pain and complications (Ahmed et al. 2020).

Intraoperative tourniquet use is routinely used in extremity surgery. However, intraoperative tourniquet application alters normal physiology and is associated with several complications (Kumar, Railton, and Tawfic 2016), including ischemia-reperfusion injury, which significantly limits their clinical use (Thai P. Trana, et al. 2012). Tourniquet deflation is a critical step because it causes a sudden decrease in central venous pressure and mean arterial pressure (MAP). According to (Zarrouki, Abouelhassan, and Samkaoui 2017), cardiac arrest has been reported after postoperative tourniquet cuff deflation.

Tourniquet deflation can cause acute hypotension (Maher, Baz, and Farid 2021). This can occur because the sympathetic nervous system regulates arterial blood pressure by maintaining vascular tone, but this varies from patient to patient. Patient variability in sympathetic nerve activity leads to varying responses to hemodynamic disturbances. The higher the baseline sympathetic nerve activity, the greater the decrease in arterial blood pressure due to hemodynamic disturbances (Kim et al. 2021).

To date, there is no specific procedure or Standard Operating Procedure (SOP) for post-TKA tourniquet deflation. Post-operative tourniquet deflation is still performed directly, with various potential complications. According to research (Elbadrawy and Aboelela 2021a), gradual or intermittent tourniquet deflation results in more stable hemodynamic values. Therefore, this study aims to analyze the comparison of direct and gradual tourniquet deflation on blood pressure changes in TKA patients.

METHOD

The research design used a quasi-experiment with a two-group pre-post test control design approach. The population was all Total Knee Arthroplasty (TKA) surgery patients in the Central Surgical Installation Room of Dr. Soedono Regional General Hospital, East Java Province. The sample was selected using the Simple Random Sampling technique, with n = 24 divided into an intervention group of n = 12 and a control group of n = 12. Inclusion criteria included age 50-85 years, type of SAB anesthesia, and no history of hypertension. The study was conducted from January to March 2024. The intervention was carried out by applying a tourniquet pressure of 300 mmHg to the patient's thigh (according to standard operating procedures). The intraoperative tourniquet pressure used was 300 mmHg with a maximum duration of 2 hours. Gradual deflation was carried out by reducing the tourniquet pressure by 100 mmHg every minute, while in direct deflation the pressure was reduced by 300 mmHg directly. The research instruments used a pneumonic tourniquet, a blood pressure monitor, and an observation sheet. Data analysis used an independent T-test to see the difference in systolic and diastolic blood pressure values before and after the intervention in both groups. This study was carried out by paying attention to the ethical principles of confidentiality and beneficiency. It has obtained informed consent from respondents and meets ethical standards with Number 0624010020/KEPK/STIKES-PEMK-AB/JBG/I/2024 at KEPK STIKES Pemkab Jombang.

RESULTS

The research results can be presented in the following table:

Table 1. Respondent Characteristics Data based on age and gender

Age	n=24	(n)%
< 70 years	19	79
70 - 80 years	5	21
> 80 years	0	0
Total	24	100
Gender	n=24	(n)%
Male	6	25
Female	18	75
Total	24	100

Based on Table 1, almost all respondents were aged <70 years (n=19) and <70 years (n=50). The most common age group undergoing TKA was 50-60 years (n=12). Regarding gender, the majority of respondents were female (n=18) and 75%.

Difference in Systolic Blood Pressure (Pre) between the Gradual and Immediate Groups

The average systolic blood pressure before intervention in the gradual group was 128.83 with a standard devi-

ation of 6.847. The average systolic blood pressure before intervention in the immediate group was 140.08 with a standard deviation of 17.365. The mean difference in systolic blood pressure before intervention between the gradual and immediate groups was -11.250. The significance value was 0.055. Since the ρ value was >0.05, it was concluded that there was no difference in systolic blood pressure before intervention between the gradual and immediate groups.

Table 2. Analysis of the decrease in systolic and diastolic blood pressure in both groups Pre and Post

Groups	Mean	Std. Deviation	Mean Difference	Sig	Description
Pre-graded Diastole	128.83	6.85	-4.08	0.011	Description: There has been a significant decline
Post-graded Diastole	124.75	10.38			
Pre-graded Systole	84.42	8.58	-6.17	0.000	Description: There has been a significant decline
Post-graded Systole	78.25	7.94			
Direct Pre Diastole	140.08	17.36	-18.42	0.019	Description: There has been a significant decline
Direct Post Diastole	121.67	15.79			
Direct Pre Systole	81.83	7.92	-10.50	0.000	Description: There has been a significant decline
Direct Post Systole	71.33	6.83			

Data source: primer 2024

Table 3. Analysis of differences in systolic and diastolic blood pressure Pre and Post in both groups

Tekanan Darah	Groups	Mean	SD	Equality of Variances (sig)	Sig	Mean Difference	Description
Systole_Pre	Gradual	128.83	6.847	0,017	0,055	-11.250	No difference
	Direct	140.08	17.365				
Disastole_Pre	Gradual	84.42	8.575	0,963	0,451	2.583	No difference
	Direct	81.83	7.918				
Systole_Post	Gradual	124.75	10.385	0,478	0,578	3.083	No difference
	Direct	121.67	15.790				
Diastole_Post	Gradual	78.25	7.944	0,379	0,032	6.917	There is a difference
	Direct	71.33	6.827				

Data source: primer 2024

Difference in Diastolic Blood Pressure (Pre) between the Sustained and Immediate Groups

The mean diastolic blood pressure before intervention in the gradual group was 84.42 with a standard deviation of 8.575. The mean diastolic blood pressure before intervention in the immediate group was 81.83 with a standard deviation of 7.918. The mean difference in diastolic blood pressure before intervention between the gradual and immediate groups was 2.583. The significance value was 0.451, and since the ρ value was >0.05, it was concluded that there was no difference in diastolic blood pressure before intervention between the gradual and immediate groups.

Difference in Systolic Blood Pressure (Post) between the Sustained and Immediate Groups

The mean systolic blood pressure after intervention in the gradual group was 124.75 with a standard deviation of 10.385. The mean systolic blood pressure after intervention in the immediate group was 121.67 with a standard deviation of 15.790.

The mean difference in systolic blood pressure after in-

tervention between the gradual and immediate groups was 3.083. The significance value was 0.578, and since the ρ value was >0.05, it was concluded that there was no difference in systolic blood pressure after intervention between the gradual and immediate groups.

Difference in Diastolic Blood Pressure (Post) between the Maintained and Immediate Groups

The mean diastolic blood pressure after intervention in the gradual group was 78.25 with a standard deviation of 7.944. The mean diastolic blood pressure after intervention in the immediate group was 140.08 with a standard deviation of 6.827. The mean difference in diastolic blood pressure after intervention between the gradual and immediate groups was 6.917. The significance value was 0.032, and since the ρ value was <0.05, it was concluded that there was a difference in diastolic blood pressure after intervention between the gradual and immediate groups.

Difference in Systolic Blood Pressure (Pre) between the sustained group and the immediate group

The significance value is 0.055, since the ρ value is > 0.05, it is concluded that there is no difference in systolic blood pressure before the intervention between the gradual group and the immediate group.

Difference in Diastolic Blood Pressure (Pre) between the sustained and immediate groups

The significance value is 0.451, since the ρ value is > 0.05, it is concluded that there is no difference in diastolic blood pressure before the intervention between the gradual and immediate groups.

Difference in Systolic Blood Pressure (Post) between the sustained and immediate groups

The significance value is 0.578, since the ρ value is > 0.05, it is concluded that there is no difference in systolic blood pressure after the intervention between the gradual and immediate groups.

Difference in Diastolic Blood Pressure (Post) between the sustained and immediate groups

The significance value is 0.032, since the ρ value is < 0.05, it is concluded that there is a difference in diastolic blood pressure after the intervention between the gradual and immediate groups.

DISCUSSION

Table 1 shows that almost all respondents were aged <70 years, or 79%. Based on the results of a study (Lee, Kim, and Lee 2020) that analyzed the optimal age for patients undergoing TKA with the aim of optimizing the balance between benefits and risks (revision rates and mortality according to age), the results of a review of 39 articles did not show a consistent optimal age for undergoing TKA, but there was a consensus that TKA is good for patients in their 70s. Based on the analysis of revision rates, there was a consensus that revision rates tended to increase in TKA in younger patients, but no significant differences were observed in patients aged >70 years. In the mortality analysis, there was a consensus that mortality was not significantly different in patients aged <80 years, but tended to increase with age.

The best TKA results can be achieved around age 70, and no significant difference in revision or mortality rates has been observed between ages 70 and 80; however, mortality rates tend to increase with age. Therefore, the early 70s can be recommended as the optimal age for TKA.

Other references state that recommendations for surgery are based on the patient's pain and disability, not age. Most patients undergoing total knee replacement are aged 50 to 80, but orthopedic surgeons evaluate patients individually. Total knee replacements have been successfully performed in patients of all ages, from adolescents with juvenile arthritis to elderly patients with degenerative arthritis (Marecek 2024).

Table 1 shows that the majority of respondents were female, at 18, or 75%. In women over age 50 (the estimated age of menopause), the incidence of osteoarthritis (OA) increases more sharply in women than in men. This is associated with estrogen, which can increase the synthesis of proteoglycans, proteins in connective tissue that provide support for body structures (Lapsley, Kohrt, and M 2010). Postmenopausal women, who experience decreased estrogen, develop radiographic evidence of knee arthritis (Hame and Alexander 2013). Therefore, hormonal differences, where women over 50 experience decreased estrogen, may play a role in the development of osteoarthritis in women.

Table 2 shows a significant decrease in systolic and diastolic blood pressure in both groups, indicating that intraoperative tourniquet use impacts the hemodynamic status (blood pressure) of TKA patients, whether the patient underwent gradual or immediate tourniquet deflation. Tourniquet deflation causes hemodynamic changes (changes in blood volume and metabolic processes in the ischemic limb), leading to systemic circulatory system complications such as hypotension, metabolic acidosis, hyperkalemia, myoglobulinemia, myoglobinuria, and possible renal failure. This is also known as "metabolic myonephropathy syndrome."

This is highly dependent on the size of the limb, the duration of the tourniquet application, and the patient's overall physiological status (Feng et al. 2013). Therefore, close monitoring of the patient's blood pressure and hemodynamic status, as well as sound preoperative preparation, is essential for patients at risk of hemodynamic deterioration after TKA surgery due to tourniquet deflation. Based on table 3, there was no significant difference in systolic and diastolic blood pressure in the pre-test of both groups, there was no significant difference in systolic blood pressure in the post-test of both groups, however there was a significant difference in diastolic blood pressure in the post-test of both groups where the gradual deflation group showed a smaller difference in blood pressure decrease. Although there was no significant difference in systolic blood pressure after tourniquet deflation between the two groups, a significant difference occurred in diastolic blood pressure between the two groups after tourniquet deflation. Based on these data, the group that underwent gradual tourniquet deflation showed a more stable blood pressure condition than the immediate deflation group. Conversely, the direct tourniquet deflation group showed a greater decrease in blood pressure than the gradual deflation group.

The results of this study align with those that concluded that gradual tourniquet release is associated with greater hemodynamic performance and reduces the rate of acute systemic metabolic changes associated with limb reperfusion (Almeida M, De Sousa E 2019), thus minimizing the drastic drop in blood pressure after deflation and making it the preferred method of tourniquet deflation after TKA surgery compared with direct deflation.

However, these results need to be further developed by including more hemodynamic indicators and considering the risk of systemic complications that increases over time, particularly in patients with morbid obesity, a history of peripheral vascular surgery, and severe left ventricular dysfunction, as well as in elderly and trauma patients (Besir and Tugcugil 2019). Further research is also needed to consider the use of intermittent tourniquet deflation methods. Intermittent tourniquet deflation is performed with three cycles of deflation-reinflation (deflation for 10 seconds and reinflation for 50 seconds). This method produces more stable hemodynamics, less tachycardia and hypotension, less acidosis, less hyperlactemia, and less anemia (Elbadrawy and Aboelela 2021). The use of gradual and intermittent tourniquet deflation methods produces more stable hemodynamic conditions than direct deflation, so the use of gradual and intermittent tourniquet deflation methods can be considered as a deflation method while still based on the lower risk of complications experienced by TKA patients.

CONCLUSION

There was a significant difference in blood pressure reduction after both gradual and direct tourniquet deflation. The decrease in both systolic and diastolic blood pressure in the gradual deflation group was smaller compared to the direct deflation group, so gradual deflation is more effective in minimizing the risk of hypotension and the risk of other local and systemic complications. Nurses are required to pay attention to the post-TKA tourniquet deflation action protocol and the results of this study are expected to be considered in determining standard operating procedures for the post-TKA tourniquet deflation method, with the emphasis that gradual tourniquet deflation ensures that the patient's blood pressure tends to be more stable than direct deflation.

A limitation of this study is the intervention of administering a tourniquet pressure of 300 mmHg in gradual and direct deflation in accordance with the existing SOP at Dr. Soedono Hospital, East Java, but did not consider intermittent deflation which can produce more stable hemodynamics and acid-base parameters. Intermittent deflation produces more stable hemodynamic, acid-base, and metabolic parameters. Monitoring tourniquet time, tourniquet pressure, and intracranial pressure in patients undergoing orthopedic surgery also needs to be considered as parameters.

SUGGESTION

Hemodynamic status measurement after deflation can be done by measuring the average pulse rate and blood pressure indicators for 15 minutes in the operating room and at the following times: before induction of anesthesia (initial), after inflating the tourniquet, 1 minute before deflating the tourniquet (pre-deflation), after deflation of the tourniquet (10 minutes post-deflation), and changes in blood pressure and maximum heart rate. Critical hypotension occurs when systolic blood pressure drops below 80 mmHg and critical bradycardia occurs when the heart rate is <45 beats/minute (Maher, Baz, and Farid 2021). so that this measurement method can describe the hemodynamic status more accurately.

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