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Original Article

Comparison between the Effect of Trendelenburg 20 Degree and Straight Leg Raising 45 Degree Positions on The Hemodynamics After Tourniquet Deflation in Knee Arthroscopy

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ABSTRACT

Background: Deflation of the pneumatic tourniquet after orthopedic surgery is associated with multiple cardiovascular adverse effects [hypotension and tachycardia]. Trendelenburg position or passive leg raising [PLR] are commonly used as the initial treatment of shock and hypotension

Aim of the work: To compare between Trendelenburg position 20° and passive leg raising 45° regarding the incidence of post-tourniquet deflation cardiovascular adverse effects in patients undergoing unilateral knee arthroscopy.

Patients and methods: This prospective study included 98 cases that underwent unilateral knee arthroscopy. Patients were randomly allocated into two groups; group [1] included 49 cases who were exposed to the Trendelenburg position after deflation, and group [2] included the remaining cases who had the straight leg raising test after deflation. Mean arterial pressure, heart rate, and need for vasoactive substances were recorded.

Results: No significant difference was noticed between the two groups regarding demographic variables, heart rate before tourniquet deflation, and one-minute after its deflation. However, there was a significant difference between the same groups on the subsequent readings apart from the last one. Also, group [1] showed significantly higher mean arterial pressure [MAP] compared to group [2] after deflation. Hypotension was more significantly encountered in group [2], and thus ephedrine requirements were increased.

Conclusion: Trendelenburg position appears to be more efficacious when compared to the straight leg raising, regarding the prevention of cardiovascular adverse effects associated with deflation.

Keywords: Trendelenburg Position; Straight Leg Raising Test; Tourniquet Deflation; Knee Surgery; Hypotension.

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* Main subject and any subcategories have been classified according to the research topic.

INTRODUCTION

In orthopedic surgeries, the pneumatic tourniquet is usually used as it helps to decrease operative bed bleeding, and thus, maintaining a clean and dry surgical field allowing easy and clear identification of the anatomical structures. Despite that advantage, after its deflation, there is a blood volume shift towards that ischemic area, which may decrease cardiac preload leading to hypotension [1].

Hemodynamic changes after tourniquet deflation include; hypotension, tachycardia and increase in cardiac index [2].

These changes may be insignificant for healthy individuals but, risky for patients with compromised cardiovascular system and geriatric population [2, 3].

Hypovolemia is a common problem in many clinical situations. The mortality of hypovolemic shock is directly related to the severity and duration of organ hypoperfusion; prompt volume replacement is the hallmark of success in managing the hypovolemic patient [4]. However, since fluid resuscitation requires some time to accomplish, maneuvers such as the Trendelenburg position or passive leg raising [PLR] are commonly used as the initial treatment of shock and hypotension [4].

Trendelenburg position is used as a recovery maneuver in patients with shock, as it increases venous return, cardiac output, and enhances tissue perfusion. It means elevation of the patient pelvis above the horizontal plane in the supine position. Since World War-I, this position along with its variations [supine position with passive leg raising] have been used in patients with symptomatic hypotension [5].

Passive leg raising test has been used to predict fluid responsiveness in critically ill patients. That test is based on a simple fact, raising the limb upwards will aid the blood contained in the lower limb vasculature to be auto-transfused in the circulation, leading to an increase in the cardiac preload [6-8].

AIM OF THE WORK

The current work designed to compare between Trendelenburg position 20° and straight leg elevation

45° regarding the incidence of post-tourniquet deflation cardiovascular adverse effects in patients undergoing unilateral knee arthroscopy.

PATIENTS AND METHODS

This prospective study was conducted at Mansoura University Hospitals during the period between January and July 2020. We included a total of 98 cases who underwent a unilateral knee arthroscopy after obtaining written consent from all cases. The study was approved by the local ethical committee of Mansoura University.

Inclusion criteria: cases older than 18 years who underwent a unilateral knee arthroscopy requiring the application of proximal tourniquet.

Exclusion criteria: cases with previous knee surgery, cardiac arrhythmia, uncontrolled systemic hypertension, unstable angina, requiring bilateral lower limb surgery and cases having American Society of Anesthesiologists [ASA] > II.

All cases are subjected to

- Clinical and radiological assessment before surgery.
- Crystalloid solution administration. At 80 to 100 ml/h for the 2 h immediately before surgery.
- Fentanyl and/or midazolam administration for anxiolysis 5 min before induction of anesthesia.
- Vital signs monitoring as heart rate, invasive arterial blood pressure [for more accurate reading] temperature, and pulse oximetry on reaching operating theatre.

Spinal anesthesia was performed in the L3–L4 interspace via a 25-gauge spinal needle after local skin sterilization, and infiltration with 2 mL of 2% lidocaine was done with a single dose of 15 mg hyperbaric bupivacaine 0.5% [3 ml] injected over 30 seconds.

Hypotension [fall of MAP by 20% or more from basal value] was corrected by fluid supplementation and/or 5 mg of ephedrine incremental.

Bradycardia [HR <50 bpm] was treated with incremental 0.5 mg of intravenous [IV] atropine. After anesthesia, the patient was placed at the supine position, and a proximal pneumatic tourniquet was applied [pressure 300-350 mmHg], and the operation was performed.

Monitoring of hemodynamics was done throughout the procedure as systolic blood pressure [SBP], diastolic blood pressure [DBP] and mean arterial pressure [MAP] via noninvasive, automated methods. The continuous electrocardiogram [ECG] allowed measurements of heart rate [HR] [Datex Ohmeda S/5 anesthesia monitor, GE Healthcare, Chalfont St. Giles, UK].

In addition, we recorded the doses of bupivacaine, ephedrine administered and the total volume of fluid administered before tourniquet deflation.

Patients were randomly divided into two groups following completion, and before tourniquet deflation using the closed envelope method. Group 1: 49 cases that had their position changed to the Trendelenburg position with head down tilt to 20°; Group 2: the remaining 49 cases who had bilateral passive leg raising to a 45° angle.

Outcome was estimated by mean arterial pressure [MAP], heart rate and need for vasopressors before deflation, and at 1-, 2-, 3-, 4-, 5-, and 10 minutes after deflation.

Statistical Analysis:

Data were analyzed using the Statistical Package of Social Science [SPSS] program for Windows [Standard version 21] [IBM®SPSS® Inc., Chicago, USA]. The normality of data was first tested with one-sample Kolmogorov-Smirnov test. Qualitative data

were described using number and percent. Association between categorical variables was tested using Chi-square test. Continuous variables were presented as mean±SD [standard deviation] for parametric data. The two groups were compared with Student “t” test. P value < 0.05 was considered statistically significant.

RESULTS

As regard demographic data, the mean age of the included cases was 25.9 and 29.49 years in groups A and B respectively. The percentages of females in group 1 were 51 while in group 2 was 61.2%. The mean values of body mass indices [BMI] were 26.78 and 28.06 kg/m² in group 1 and 2 respectively. In addition, the majority of cases in study were ASA score I. All of the previously mentioned variables were not statistically significant between the two groups [p > 0.05] [Table 1].

Regarding heart rate, there was no significant difference between the two groups before tourniquet deflation, and 1-minute after its deflation. However, there was a significant difference between two groups on the subsequent readings [2-, 3-, 4-, and 5-minute readings, p < 0.05], as group 1 showed significantly lower heart rates compared to the other group. The 10-minute reading did not differ between the two groups [p = 0.174] [Table 2].

There was no significant difference between the two groups regarding MAP before deflation. Nevertheless, group 1 showed significantly higher MAP compared to group 2 after deflation [p < 0.001] [Table 3].

Hypotension was encountered in only one case [2%] in group 1, whereas it was encountered in 7 cases [14.3%] in group 2 [p = 0.027]. ephedrine usage was significantly increased in the second group compared to the first one [2.35 vs. 0.2 mg, p = 0.025] [Table 4].

Table [1]: Demographic data in the studied groups.

		Group 1 [n= 49]	Group 2 [n= 49]	95% CI	p
Age [years]		25.90 ± 10.341	29.49 ± 9.170	-7.51, 0.33	0.072
Gender	Male	49.0% [24]	38.8% [19]	-0.3, 0.09	0.309
	Female	51.0% [25]	61.2% [30]		
BMI [kg/m ²]		26.78 ± 4.987	28.06 ± 4.340	-3.15, 0.60	0.179
ASA	I	81.6% [40]	85.7% [42]	-0.11, 0.19	0.585
	II	18.4% [9]	14.3% [7]		

Table [2]: Heart rate variation before and after tourniquet deflation in the studied groups.

Heart rate	Group 1 [n= 49]	Group 2 [n= 49]	95% CI	p
Before deflation	79.24 ± 10.315	82.61 ± 12.320	-7.92, 1.19	0.146
One minute	83.24 ± 11.163	87.96 ± 13.430	-9.67, 0.24	0.062
Two minutes	85.41 ± 11.869	93.65 ± 14.326	- 13.52, - 2.97	< 0.001
Three minutes	86.14 ± 12.295	97.02 ± 14.749	-16.32, - 5.43	< 0.001
Four minutes	86.39 ± 12.528	97.65 ± 15.019	-16.81, - 5.72	< 0.001
Five minutes	83.88 ± 12.313	96.22 ± 15.128	-17.88, - 6.82	< 0.001
10 minutes	79.41 ± 10.970	82.65 ± 12.458	-7.95, 1.46	0.174

Table [3]: Mean arterial blood pressure variation before and after tourniquet deflation in the studied groups.

MAP	Group 1 [n= 49]	Group 2 [n= 49]	95% CI	p
Before deflation	96.57 ± 8.127	96.31 ± 7.851	-2.94, 3.47	0.870
One minute	94.41 ± 9.004	85.43 ± 9.213	5.33, 12.63	< 0.001
Two minutes	91.06 ± 7.915	82.22 ± 8.806	5.48, 12.19	< 0.001
Three minutes	89.45 ± 7.887	81.43 ± 7.411	4.95, 11.09	< 0.001
Four minutes	90.71 ± 8.302	82.49 ± 7.174	5.11, 11.34	< 0.001
Five minutes	91.61 ± 8.553	84.22 ± 8.055	4.06, 10.72	< 0.001
Ten minutes	98.92 ± 9.416	90.45 ± 8.813	4.81, 12.13	< 0.001

Table [4]: Incidence of hypotension and Ephedrine dose [mg] in the studied groups.

	Group 1 [n= 49]	Group 2 [n= 49]	95% CI	p
Hypotension	2.0% [1]	14.3% [7]	0.02, 0.23	0.027
Ephedrine	0.20 ± 1.429	2.35 ± 6.132	-3.93, -0.36	0.025

DISCUSSION

Both Trendelenburg and straight leg raising positions are used for the management of acute hypotension [9].

To the best of our knowledge, there is a paucity of studies comparing both positions in the prevention of cardiovascular adverse effects associated with tourniquet deflation during lower limb orthopedic surgeries.

This study was conducted to elucidate the difference between these two positions regarding the incidence of tachycardia and hypotension after tourniquet deflation in knee arthroscopy surgery.

As shown in the methodology, the included cases were randomly divided into two groups with no significant differences regarding demo-graphics, and that ensures the good randomization and reliability of our data.

Multiple studies have reported blood pressure decrease after tourniquet deflation. Kahn and his associates reported a 19.2% decrease in MAP 1 minute after tourniquet deflation during knee arthroplasty procedures [10].

Girardis *et al.* also reported a 14% decrease in the same parameter with tourniquet deflation [11].

Furthermore, Iwama *et al.* reported a 14.5 and

12.9% decrease in systolic and diastolic blood pressure respectively following deflation of the tourniquet in lower limb surgery [12].

Regarding the passive leg raising test, in a previous study conducted by Huang *et al.*, passive leg raising was successful in preventing hypotension after tourniquet deflation compared to controls. There was a 15.1% decrease in MAP in controls, while the decrease was 4.3% in the leg raising group. Therefore, it helped to maintain hemodynamic stability after deflation compared to controls [13].

This effect could be explained by three mechanisms; first of all, rising the leg helps to move blood from the lower limb vasculature, by the effect of gravity, to the intrathoracic veins, leading to an increase in cardiac preload [14, 15].

Secondly, straight leg raising is associated with an increased systemic vascular resistance [16, 17].

Lastly, with the leg elevated during deflation, the blood shift to the ischemic limb will be significantly decreased by the effect of the gravity, that counteracts the blood flow [13].

However, leg rising is not always sufficient to prevent these cardiac adverse effects. Huang *et al.* reported that MAP decreased by 5% or more in 54.28% of the included cases. That means that it cannot completely counteract the adverse effects following tourniquet deflation [13].

This could be explained by the fact that hypotension and tachycardia are multifactorial. Not only is rapid shift of blood to the ischemic limb responsible for hemodynamic changes, but also decreased vascular resistance, operative blood loss, and the circulatory effects of the accumulated metabolites may have a role in these manifestations [11, 18, 19].

Also, Wong *et al.* reported that straight leg raising decreased MAP due to a decrease in the diastolic pressure. Thus, there is an obvious variability in the MAP responses to leg elevation among patients in different studies [20].

In addition, other multiple studies have negated any significant effect of leg rising on the heart rate [16, 20-22].

Due to the previous weak efficacy reported by the straight leg raising test, we tried to compare it with the original Trendelenburg position aiming to obtain better results in such cases.

Our results revealed that hypotension and tachycardia were significantly more encountered in the leg raising group after deflation. Also, the incidence of hypotension was higher which led to an increase in ephedrine injection requirements in the leg raising group.

According to a previous meta-analysis [23], had compared the hemodynamic changes between the two positions. Although they noticed an increase in cardiac output after both positions after one minute of application, which was more in Trendelenburg position. No conclusions could be reached regarding the effect after 10 minutes. They stated that Leg rising, in contrast, seems to have a sustained effect. However, as they use wide range definition of Trendelenburg position, total-body head down tilt of 5° to 60°, and PLR was defined as supine position with straight passive elevation of both legs at a 10° to 90° angle in the studies included in this meta-analysis, small sample size of studies, also variable patients' criteria; normo- and hypovolemic patients, so more direct and specific comparison is needed.

Other studies have compared the hemodynamic changes between the two positions [14, 24-26] and effect on heart dimensions, showed that both approaches of volume loading of the heart induced significant changes and increases of preload. However, changes were more pronounced during the "leg up" position 45° than during HDT of 6°. It is questioned whether HDT with -6° is appropriate to truly reflect hemodynamic alterations of Trendelenburg position. But they concluded that "leg up" position cannot be maintained as long as HDT due to decrease of arterial blood supply thus causing discomfort [23].

In our study, the application of Trendelenburg position of 20° had also other advantages; it was easy to apply in the modern operating tables without any negative impact on the sterilized operative field. Even if manual work was required, it was adjusted from the table control located at the patient's head without compromising the operative field. On the other hand,

leg raising may require some manual interference in some operating tables, and that caused some trouble to the surgical team and their sterilized operative field. That point is of great importance, as after deflation, bleeding may appear in the operative field, which may mandate control. Maintaining the cleanliness of the operative field is mandatory for that step. Also, in Trendelenburg position, the patient has no flexed hip, unlike leg raising, which may interfere with the surgeon orientation in other orthopedic surgeries.

Although the Trendelenburg position has been associated with gastric content regurgitation, respiratory difficulty, increased intraocular and intracranial pressures [27-29], neither of these reported drawbacks had been reported in our study. This could be due to the short time period at which the patient is positioned that way.

Our study has some limitations, first, it is a single center study. Secondly, the cardiac output [COP] should have been measured in the included cases to know the effect of both positions on COP. These drawbacks should be covered in the upcoming studies.

Conclusion: Based on the current findings, Trendelenburg position appears to be more efficacious, compared to the straight leg raising, regarding the prevention of cardiovascular adverse effects associated with tourniquet deflation.

Financial and Non-Financial Relationships and Activities of Interest

None

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International Journal

The background of the cover is a light blue gradient. It features a faint, stylized ECG (heart rate) line that runs across the entire page. In the center, there is a semi-transparent globe of the Earth. To the left of the globe, a stethoscope is depicted in a light blue color, with its chest piece resting on the globe. The overall aesthetic is clean and professional, representing the intersection of medicine and global health.

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