ORIGINAL ARTICLE

Acta Orthop Traumatol Turc 2014;48(5):483-490
doi: 10.3944/AOTT.2014.14.0068

Tourniquet use in orthopedic surgery: a descriptive survey study among Turkish orthopedic surgeons and residents in Istanbul

Merter YALÇINKAYA[1], Sami SÖKÜCÜ[1], Sinan ERDOĞAN[2], Yavuz S. KABUKÇUOĞLU[1]

[1]Metin Sabancı Baltalimanı Bone Diseases Training and Research Hospital, Department of Orthopedics and Traumatology, Istanbul, Turkey;
[2]Gaziosmanpaşa Taksim Training and Research Hospital, Department of Orthopedics and Traumatology, Istanbul, Turkey

Objective: The aim of this study was to investigate and interpret the trends in tourniquet use and the accuracy of knowledge among Turkish orthopedic physicians through face-to-face survey.

Methods: Turkish orthopedic physicians actively practicing operative orthopedics were questioned in a 12 question face-to-face survey. Personal information of physicians, preferred cuff pressure (CP) and tourniquet inflation time (TIT) and the source of the information for these preferences were questioned. Answers gathered were analyzed statistically.

Results: The survey was completed by 211 orthopedic physicians. Mean preferred CP and TIT was 247.1 mmHg and 108.6 minutes, respectively, in the upper limb (UL) and 345.02 mmHg and 122.4 minutes, respectively, in the lower limb (LL). A statistically significant correlation was found between the amount of pressure preferred in the LL and the years of practice; longer the years in practice, higher the amount of pressure preferred (r=0.144, p=0.04). Tourniquets were used for a maximum period of 120 minutes for the UL by 95.7% of participants and for the LL by 84.8%.

Conclusion: The amount of CP used by the orthopedic physicians surveyed is inconsistent with the literature with frequent use of CP higher than those scientifically recommended. The outcomes of the survey should be cautionary for orthopedic physicians to review the current utilization and replace personal teachings and experience-based methods with evidence-based best practices for tourniquet application.

Key words: Guideline; orthopedic surgery; survey; tourniquet.

Tourniquets are indispensable equipment in orthopedics used to obtain a bloodless operative field in extremity surgery and thus a safe and clear exposure of anatomical structures with reduced technical complexity in a shortened operation time.[1-4] Although widely practiced, complications with tourniquet use occur; including skin irritations, chemical burns, neurological and muscular injury, systemic metabolic effects, thromboembolism and pulmonary embolism, intraoperative breakthrough bleeding, compartment syndrome, postoperative swelling, and pain.[1,3,5-12]

Complications can generally be avoided by minimizing the cuff pressure (CP) and tourniquet inflation time (TIT).[6] However, the literature does not define an absolute standard of CP level,[13] resulting in a variety of recommendations[1-5,14-22] and the use of experience-

Correspondence: Merter Yalçınkaya, MD. Metin Sabancı Baltalimanı Kemik Hastalıkları Eğitim ve Araştırma Hastanesi, Ortopedi ve Travmatoloji Kliniği, Rumeli Hisarı Cad., No: 62, Baltalimanı 34470, Istanbul, Turkey.

Tel: +90 212- 323 70 75 e-mail: merter_99@hotmail.com

Submitted: February 20, 2014 **Accepted:** May 28, 2014

Available online at
www.aott.org.tr
doi: 10.3944/AOTT.2014.14.0068
QR (Quick Response) Code

Table 1. Survey questions.

1-	What is your academic title in the hospital? (orthopedic resident; orthopedic surgeon)
2-	How long have you been actively practicing operative orthopedics? (in months)
3-	Where do you perform surgery (more than one answer can be given)? (training and research hospital; university hospital; private hospital; state hospital; private out-patient office)
4-	Who applies and inflates the cuff to your patients? (myself; junior colleague; orthopedic theater personnel; nurse; anesthetist; other)
5-	Do you prefer using an underlying skin protection material underneath the cuff? (no; elastic stockinette; cotton cast padding; other)
6-	How do you exsanguinate the limb prior to tourniquet inflation? (do not exsanguinate; elevation only; elastic bandage; Esmarch bandage)
7-	What type of tourniquet do you most commonly prefer? (electronic; non-electronic)
	You are planning to use tourniquet for an orthopedic limb surgery in a patient who is normotensive, neither morbidly obese nor cachectic and has no medical history of sickle cell anemia, deep vein thrombosis, peripheral vascular disease, severe infection, bypass surgery or malignancy in the related extremity. According to this scenario;
8-	In the upper limb, what pressure setting do you most commonly use for your patients and what do you prefer as the maximum tourniquet inflation time? (for pressure; in mmHg, for time; in hours)
9-	In the lower limb, what pressure setting do you most commonly use for your patients and what do you prefer as the maximum tourniquet inflation time? (for pressure; in mmHg, for time; in hours)
10-	What is the basis of the information supporting your cuff pressure and tourniquet inflation time preferences as previously answered in questions 8 and 9? (there's a literature in support of my answer and I am able to cite it; I am sure literature exists that supports my answer but I can't cite it; I apply these preferences in accordance with my senior colleague's instructions; these preferences have been determined by the chief of the department and the preferences have been routinely used in surgical practices in the same manner; personal experience)
11-	Have you experienced any intraoperative or postoperative tourniquet related complications (more than one answer can be given)? (no; intraoperative breakthrough bleeding; skin injury [blister, contusion, abrasion, chemical burns]; nerve injury; muscle injury; other)
12-	Which circumstances should be considered as priority in the decision of cuff pressure (more than one answer can be given)? (a standard cuff pressure can be used for every patient; cuff pressure must be decided according to the age of the patient, circumference and other conditions of the extremity; cuff pressure must be decided according to the blood pressure; applying a pressure of "systolic blood pressure + 100 mmHg" would be adequate; applying a pressure of "systolic blood pressure x 2" would be adequate; other)

based individual preferences.[23] This multiplicity in recommendations and the lack of definite guidelines often cause confusion in determining CP and TIT, and individual preferences can lead to dangerous and unfortunate consequences.

The objectives of this study were to investigate the existing understanding of tourniquet use and the accuracy of the knowledge leading to these trends among Turkish orthopedic physicians through a face-to-face survey and to interpret the outcomes in light of the current literature.

Materials and methods

A face-to-face survey consisting of 12 questions (Table 1) was carried out to Turkish orthopaedic physicians in Istanbul who were actively participating in operative orthopaedics and regularly use tourniquets in surgery. All surveys were carried out by either the senior author (MY) or by co-authors (SS, SE) under the supervision of the senior author. The face-to-face survey was designed to ensure the participants reflected on their current understanding of the issue as if it were a regular operating day and to obtain the highest percent of responses per physicians surveyed.[24]

Physicians' personal information (academic title, years in practice, the setting of practice) and existing comprehension of tourniquet use and the source of the literature information for these preferences were questioned. For further evaluation, participants were divided into two groups with presumably different priorities to investigate any dissimilarity in tourniquet utilization: orthopedic residents (Group 1) and orthopedic surgeons (Group 2).

Based on the literature,[14,17,19,20,25] CPs of 200 mmHg for the upper limb (UL) and 250 mmHg for the lower limb (LL) were selected as the cut-off values as the maximum amount of pressure that can be applied. These values were used to evaluate the consistency of the physicians' preferences with the recommendations in the literature.

For questions 3, 11, and 12, participants were al-

Table 2. Survey results; personal information of the physicians.

Q1 What is your academic title in the hospital?			
		Number	**Percent**
Orthopedic resident	Group 1	97	46%
Orthopedic surgeon	Group 2	114	54%

Q2 How long have you been actively practicing operative orthopedics?			
	Mean±Standard Deviation (months)	**Range; Median (months)**	**P value***
Group 1	30.2±16.4	3 to 65; 27	**0.0001**
Group 2	154.9±90.3	60 to 480; 132	
Total	97.6±91.6	3 to 480; 62	

Q3 Where do you perform surgery? (More than one answer can be given).		
	Number	**Percent**
Training and research hospital	148	70.1%
University hospital	45	21.3%
Private hospital	23	10.9%
State hospital	18	8.5%
Private outpatient office	1	0.5%

*T-test. Significant p values are indicated in bold.

lowed to select more than one answer which may result in a total percentage greater than 100.

Results were analyzed using SPSS v.11.5.0 software (SPSS Inc., Chicago, IL, USA). Statistical analyses were performed using the Pearson chi-square test, the t-test and Pearson's correlation test. Significance level was set at $p<0.05$.

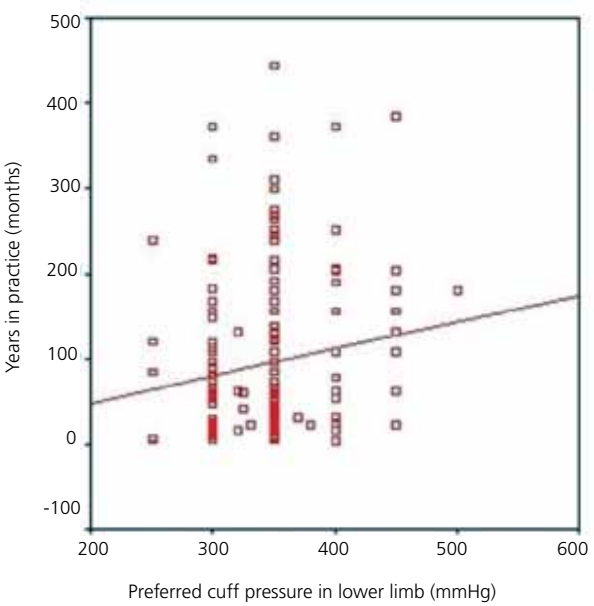

Fig. 1. The correlation between the years in practice and preferred cuff pressure settings in lower limb was statistically significant (Pearson's correlation test; r=0.144, p=0.04). [Color figure can be viewed in the online issue, which is available at www.aott.org.tr]

Results

The study included 211 orthopedic physicians who completed the survey. Mean years in practice was 97.6±91.6 (range: 3 to 480; median: 62) months. There were 97 (46%) orthopedic residents in Group 1 and 114 (54%) orthopedic surgeons in Group 2. Mean years in practice was 30.2±16.4 (range: 3 to 65; median: 27) months in Group 1 and 154.9±90.3 (range: 60 to 480; median: 132) months in Group 2 (t-test; p=0.0001). Detailed survey results on personal information of the physicians and current practices are shown in Table 2 and 3.

The majority of the participants used electronic tourniquet utilization (96 participants [99%] in Group 1 and 113 [99%] in Group 2) with a cotton cast padding under the cuff (94 participants [96.9%] in Group 1 and 113 [99%] in Group 2) and exsanguinated the limb via an Esmarch bandage (83 participants [85.6%] in Group 1 and 90 [78.9%] in Group 2) prior to tourniquet inflation.

The number of participants who applied and inflated the cuff himself/herself were significantly higher in Group 1 (59 participants [60.8%] vs 41 participants [36%]. Pearson's chi-squared test; p=0.0001). This process was requested from a junior colleague in Group 2 in 35.1% of occasions and 5.2% in Group 1. This difference was statistically higher (Pearson's chi-squared test; p=0.0001).

Table 3. Survey results; current practices.

Q4 Who applies and inflates the cuff to your patients?

	Group 1 Number	Group 2 Number	Total	Percent
Myself	59	41	100	47.4%
Junior colleague	5	40	45	21.3%
Orthopedic theater personnel	32	32	64	30.3%
Nurse	0	0	0	0%
Anesthetist	1	0	1	0.5%
Other	0	1	1	0.5%

Q5 Do you prefer using an underlying skin protection material underneath the cuff?

	Group 1 Number	Group 2 Number	Total	Percent
No	0	1	1	0.5%
Elastic stockinette	2	0	2	0.9%
Cotton cast padding	94	113	207	98.1%
Other	1	0	1	0.5%

Q6 How do you exsanguinate the limb prior to tourniquet inflation?

	Group 1 Number	Group 2 Number	Total	Percent
Do not exsanguinate	0	4	4	1.9%
Elevation only	7	19	26	12.3%
Elastic bandage	7	1	8	3.8%
Esmarch bandage	83	90	173	82%

Q7 What type of tourniquet do you most commonly prefer?

	Group 1 Number	Group 2 Number	Total	Percent
Electronic	96	113	209	99.1%
Non-electronic	1	1	2	0.9%

Q8 In the upper limb, what pressure setting do you most commonly use for your patients and what do you prefer as the maximum tourniquet inflation time?

Cuff pressure	Mean±Standard Deviation (mmHg)	Range; Median (mmHg)	P value*
Group 1	250.21±32.156	150 to 300; 250	0.248
Group 2	244.44±37.946	150 to 350; 250	
Total	247.14±35.386	150 to 350; 250	
Inflation time	Mean±Standard Deviation (hours)	Range; Median (hours)	P value*
Group 1	1.84±0.366	1 to 3; 2	0.313
Group 2	1.79±0.35	0.75 to 2.5; 2	
Total	1.81±0.358	0.75 to 3; 2	

Q9 In the lower limb, what pressure setting do you most commonly use for your patients and what do you prefer as the maximum tourniquet inflation time?

Cuff pressure	Mean±Standard Deviation (mmHg)	Range; Median (mmHg)	P value*
Group 1	338.37±32.416	250 to 450; 350	**0.028**
Group 2	350.88±45.748	250 to 500; 350	
Total	345.02±40.457	250 to 500; 350	
Inflation time	Mean±Standard Deviation (hours)	Range; Median (hours)	P value*
Group 1	2.02±0.314	1.5 to 3; 2	0.477
Group 2	2.05±0.335	1.5 to 3; 2	
Total	2.04±0.325	1.5 to 3; 2	

Table 3. (continued) Survey results; current practices.

Q10 What is the basis of the information supporting your cuff pressure and tourniquet inflation time preferences as previously answered in questions 8 and 9?

	Group 1 Number	Group 2 Number	Total	Percent
There's a literature in support; able to cite it	17	41	58	27.5%
There's a literature in support; not able to cite it	5	21	26	12.3%
Determined by senior colleague	56	8	64	30.3%
Determined by the chief of the department	19	12	31	14.7%
Personal experience	0	32	32	15.2%

Q11 Have you experienced any intraoperative or postoperative tourniquet related complications? (More than one answer can be given).

	Group 1 Number	Group 2 Number	Total	Percent
No	31	19	50	23.7%
Intraoperative breakthrough bleeding	40	49	89	42.2%
Skin injury	19	31	50	23.7%
Nerve injury	11	49	60	28.4%
Muscle injury	0	1	1	0.5%
Other	8	4	12	5.7%

Q12 Which circumstances should be considered as priority in the decision of cuff pressure? (More than one answer can be given).

	Group 1 Number	Group 2 Number	Total	Percent
A standard cuff pressure for every patient	4	8	12	5.7%
According to the age of the patient, circumference and other conditions of the extremity	38	51	89	42.2%
According to the blood pressure	51	53	104	49.3%
A pressure of "systolic blood pressure + 100 mmHg" would be adequate	21	27	48	22.7%
A pressure of "systolic blood pressure x 2" would be adequate	3	4	7	3.3%
Other	0	0	0	0%

*T-test. Significant p values are indicated in bold.

The most commonly preferred CP setting in the UL and the maximum TIT in both the UL and LL was similar in the two groups (t-test; p=0.248, p=0.313 and p=0.477, respectively) whereas Group 1 preferred significantly lower CP settings in LL compared to Group 2 (t-test; p=0.028) (Table 3).

Correlations of years in practice versus preferred CP settings and maximum TIT in the UL and LL were further investigated. The correlation between the years in practice and preferred CP settings in the LL was statistically significant (Pearson's correlation test; r=0.144, p=0.04). As the years in practice increased, preferred CP in LL increased (Fig. 1) whereas the years in practice was not significantly correlated with preferred CP settings in UL, the maximum TIT in both UL, or LL (Pearson's correlation test; r=-0.015, p=0.833; r=-0.121, p=0.079 and r=-0.031, p=0.659, respectively).

In current practice, the percent of participants in Group 2 who preferred CP and TIT based on studies in the literature they could cite were higher than in Group 1 (17 [17.5%] vs 41 [36%]. Pearson's chi-squared test; p=0.0001). Conversely, senior colleague's instructions were more significant in Group 1 than Group 2 (56 [57.7%] vs 8 [7%]. Pearson's chi-squared test; p=0.0001). CP and TIT preferences according to personal experiences were significantly higher in Group 2 (none [0%] vs 32 [28.1%]. Pearson's chi-squared test; p=0.0001).

Out of 84 (39.8%) participants who stated that they chose CP based on the literature, only 22 (26.2%) in the UL and 4 (4.8%) in the LL preferred CP lower than 200 and 250 mmHg, respectively. Out of 164 (77.7%) participants who stated that they prefer CP over 200 mmHg in the UL, 62 (37.8%) claimed that their preferences were based on the literature and 43 (69.4%) out of these 62 were certain that they could cite the literature which supported their utilization. Likewise, in the LL, out of

202 (95.7%) participants who stated that they prefer CP over 250 mmHg, 81 (40.1%) claimed that their preferences were based on the studies in the literature, and 56 out of the 81 (69.1%) were certain that they could cite the literature which supported their utilization.

Two hundred and two (95.7%) participants in the UL and 179 (84.8%) in the LL reported 2 hours as the maximum TIT, respectively.

Participants who did not experience any intraoperative or postoperative tourniquet related complications was higher in Group 1 (31 [32%] vs 19 [16.7%] whereas complications of skin and nerve injuries were more frequently reported in Group 2 compared to Group 1 (skin injury: 19 participants [19.6%] in Group 1, 31 participants [27.2%] in Group 2; nerve injury: 11 participants [11.3%] in Group 1, 49 participants [43%] in Group 2).

The vast majority of participants in both groups reported that the age of the patients, circumference and other conditions of the extremity (38 participants [39.2%] in Group 1, 51 participants [44.7%] in Group 2) or the blood pressure (51 participants [52.6%] in Group 1, 53 participants [46.5%] in Group 2) should be considered as a priority in the decision of CP.

Discussion

While some studies have reported that the use of tourniquets is not mandatory in specific areas of orthopedic surgery,[7,10,26-29] they continue to be used frequently used by orthopedic surgeons due to their benefits in maintaining a bloodless surgical field.[1-4,30] Complications[5,18,31] due to utilization are preventable if properly used according to widely accepted recommendations.[30] As a part of safe tourniquet use, an electronic pneumatic tourniquet utilization,[2,31] wider,[1,2,4,5,10,12,15,18,31,32] contoured,[1,2,18,31] and curved[12,15] cuffs, or if obtainable, cuffs having individualized width, length and shape[3,5,15,18] with an underlying skin protection material underneath such as soft padding[3-5,18,33] or elastic stockinette[2,18,34] have been frequently recommended by numerous studies. Exsanguination with elastic[18] or Esmarch bandages[2,18] followed by rapid cuff inflation[18] and maintaining the inflated cuff by a maximum time of 2 hours[1-5,34,35] with 10-minute reperfusion intervals[3,12,31,35] after every 2 hours of cuff inflation are other most commonly used methods among the vast majority of studies on safe tourniquet use. In the present study, the participants' responses regarding these issues were coherent with the literature.

The ideal maximal safe tourniquet CP remains controversial. Using standard cuff inflation pressures,[1,5] which are usually higher than necessary,[1,14,19,23, 36] is one of the conventional tendencies of orthopedic surgeons. Other recommendations such as CP of twice the systolic blood pressure,[15,22] calculating CP according to an equation,[17,22,25] adding a safety margin to systolic blood pressure[1,5,15,20,37] or adding a safety margin to limb occlusion pressure (LOP) (also known as arterial occlusion pressure or Doppler occlusion pressure) have been more recently suggested.[1,2,12,14-16,18,31]

Considering such conflict, the use of patient age, limb circumference and other conditions of the extremity as factors in the selection of CP, as 42.2% of the participants in the recent study did, seems reasonable. Employing a CP according to blood pressure or by adding a safety margin to systolic blood pressure (as practiced by 49.3% and 22.7% of the participants in the recent study, respectively) are no longer considered contemporary methods due to the validity of LOP. Limb occlusion pressure, determined by Doppler ultrasound, pulse oximeters or photoplethysmographs, is the minimum pressure applied to occlude the arterial blood flow into the limb distal to the cuff.[2,12,31] Minimizing the CP value is possible when the tourniquet pressure is set on the basis of LOP,[2,12] thus reducing tourniquet-related complications.[31] It was a striking outcome of the current study that none of the participants reported using LOP for the determination of CP. Despite recommendations based on logical reasons in the literature, the utilization of LOP seems to be underrated by other societies' orthopedic surgeons, similar to our participants.[6,23,36,38]

Overpressurization is one of the common problems encountered in similar surveys.[6,23,36] Maximum pressure of 200 to 250 mmHg and 250 to 300 mmHg of CP for the UL and LL, respectively, have been frequently recommended.[1,14,17,19,20,25] In the current study, the participants' preferences were well above these recommendations, particularly in the LL. Ignoring LOP might have led the participants to prefer a CP higher than necessary. Meanwhile, the statistically significant positive correlation between the years in practice and preferred CP settings in the LL can be considered as a divergence from scientific facts or explained by the presence of more recently trained junior orthopedic physicians who fully understood the seriousness of the subject. This query will continue to be a matter of debate.

The lack of assimilation and knowing or misinterpretation of the literature about the utilization of tourniquet might have been another reason for the overpressurization preferred by the participants of this study. The results in the evaluation of the consistency of the participants' preferences with the frequent recommenda-

tions in the literature clearly revealed the lack of knowledge and misinterpretation of the literature. Only a small percentage of participants who reported that they select CP based on the literature in fact used pressures within the safe margins. A remarkable number of participants using higher pressures were certain that they could cite the literature which supported their utilization.

Suboptimal knowledge and lack of consensus on safe tourniquet use is nothing surprising and has been established in previous surveys applied in other orthopedic societies.[6,19,23,30,36,38] Thus, in the presence of a recent study reporting that most surgeons learn how to use pneumatic tourniquets by instruction from their senior colleagues due to the absence of formal teaching in the curriculum on the utilization of tourniquets,[38] the level of knowledge becomes much more important, especially for the 45% of participants in our study who apply CP and time preferences in accordance with the senior colleague's or the chief of the department's instructions. Inheritance of inaccurate instructions may cause unfortunate outcomes for junior orthopedic residents in the future. Allowing orthopedic theater personnel to apply and to inflate the cuff to the patients as 30.3% of the participants in the current study did is inadmissible and should be alarming. The lack of understanding regarding exsanguinator and tourniquet use is also prevalent amongst operating theater personnel, as was revealed in a recent study.[30]

Certainly, while the value of personal experiences acquired over the years cannot be ignored, they must be renewable and the preferences based on these experiences must be consistent with scientific facts. This study was designed to investigate the trends in tourniquet use and to evaluate the consistency with the literature among Turkish orthopedic physicians as well as to point out the misconceptions in utilization of tourniquets. Therefore, the results of the study cannot be used as a recommended guideline. However, the outcomes of this survey must warn the orthopedic society that the current utilization, especially optimum tourniquet pressure value, should be reviewed. We believe that the Turkish Society of Orthopedics and Traumatology must take action to raise the awareness and to improve the knowledge of safe tourniquet use by reorganizing the formal orthopedic curriculum. Sharp guidelines to minimize the cuff pressure and tourniquet time are essential to prevent tourniquet-related complications for patient safety. Consequently, what we think we know may not be correct at all. Thus, evidence-based practices must take the place of personal teachings and experience-based practices in the course of tourniquet application.

Conflics of Interest: No conflicts declared.

References

1. Fitzgibbons PG, Digiovanni C, Hares S, Akelman E. Safe tourniquet use: a review of the evidence. J Am Acad Orthop Surg 2012;20:310-9. CrossRef
2. Noordin S, McEwen JA, Kragh JF Jr, Eisen A, Masri BA. Surgical tourniquets in orthopaedics. J Bone Joint Surg Am 2009;91:2958-67. CrossRef
3. Kam PC, Kavanagh R, Yoong FF. The arterial tourniquet: pathophysiological consequences and anaesthetic implications. Anaesthesia 2001;56:534-45. CrossRef
4. Cox C, Yao J. Tourniquet usage in upper extremity surgery. J Hand Surg Am 2010;35:1360-1. CrossRef
5. Sharma JP, Salhotra R. Tourniquets in orthopedic surgery. Indian J Orthop 2012;46:377-83. CrossRef
6. Younger AS, Kalla TP, McEwen JA, Inkpen K. Survey of tourniquet use in orthopaedic foot and ankle surgery. Foot Ankle Int 2005;26:208-17.
7. Konrad G, Markmiller M, Lenich A, Mayr E, Rüter A. Tourniquets may increase postoperative swelling and pain after internal fixation of ankle fractures. Clin Orthop Relat Res 2005;433:189-94. CrossRef
8. Kornbluth ID, Freedman MK, Sher L, Frederick RW. Femoral, saphenous nerve palsy after tourniquet use: a case report. Arch Phys Med Rehabil 2003;84:909-11. CrossRef
9. Hirota K, Hashimoto H, Kabara S, Tsubo T, Sato Y, Ishihara H, et al. The relationship between pneumatic tourniquet time and the amount of pulmonary emboli in patients undergoing knee arthroscopic surgeries. Anesth Analg 2001;93:776-80. CrossRef
10. Omeroğlu H, Uçaner A, Tabak AY, Güney O, Biçimoğlu A, Günel U. The effect of using a tourniquet on the intensity of postoperative pain in forearm fractures. A randomized study in 32 surgically treated patients. Int Orthop 1998;22:369-73. CrossRef
11. Yang JH, Lim H, Yoon JR, Jeong HI. Tourniquet associated chemical burn. Indian J Orthop 2012;46:356-9. CrossRef
12. Pedowitz RA. Tourniquet-induced neuromuscular injury. A recent review of rabbit and clinical experiments. Acta Orthop Scand Suppl 1991;245:1-33. CrossRef
13. Ducic I, Chang S, Dellon AL. Use of the tourniquet in reconstructive surgery in patients with previous ipsilateral lower extremity revascularization: is it safe? A survey. J Reconstr Microsurg 2006;22(3):183-9. CrossRef
14. Reid HS, Camp RA, Jacob WH. Tourniquet hemostasis. A clinical study. Clin Orthop Relat Res 1983;177:230-4.
15. Pedowitz RA, Gershuni DH, Botte MJ, Kuiper S, Rydevik BL, Hargens AR. The use of lower tourniquet inflation pressures in extremity surgery facilitated by curved and wide tourniquets and an integrated cuff inflation system. Clin Orthop Relat Res 1993;287:237-44.

16. Tredwell SJ, Wilmink M, Inkpen K, McEwen JA. Pediatric tourniquets: analysis of cuff and limb interface, current practice, and guidelines for use. J Pediatr Orthop 2001;21:671-6. CrossRef
17. Levy O, David Y, Heim M, Eldar I, Chetrit A, Engel J. Minimal tourniquet pressure to maintain arterial closure in upper limb surgery. J Hand Surg Br 1993;18:204-6.
18. Aorn Recommended Practices Committee. Recommended practices for the use of the pneumatic tourniquet in the perioperative practice setting. Aorn J 2007;86:640-655.
19. Tejwani NC, Immerman I, Achan P, Egol KA, McLaurin T. Tourniquet cuff pressure: The gulf between science and practice. J Trauma 2006;61:1415-8. CrossRef
20. Kutty S, McElwain JP. Padding under tourniquets in tourniquet controlled surgery: Bruner's ten rules revisited. Injury 2002;33:75. CrossRef
21. Tuncali B, Karci A, Bacakoglu AK, Tuncali BE, Ekin A. Controlled hypotension and minimal inflation pressure: a new approach for pneumatic tourniquet application in upper limb surgery. Anesth Analg 2003;97:1529-32. CrossRef
22. Tuncali B, Karci A, Tuncali BE, Mavioglu O, Ozkan M, Bacakoglu AK, et al. A new method for estimating arterial occlusion pressure in optimizing pneumatic tourniquet inflation pressure. Anesth Analg 2006;102:1752-7. CrossRef
23. Kalla TP, Younger A, McEwen JA, Inkpen K. Survey of tourniquet use in podiatric surgery. J Foot Ankle Surg 2003;42:68-76. CrossRef
24- Selecting The Method of Data Collection. In: Czaja R, Blair J, editors. Designing surveys. A Guide to Decisions and Procedures. 2nd ed. California: Pine Forge Press, Sage Publications; 2005. p. 33-58.
25. Van Roekel HE, Thurston AJ. Tourniquet pressure: the effect of limb circumference and systolic blood pressure. J Hand Surg Br 1985;10:142-4. CrossRef
26. Abdel-Salam A, Eyres KS. Effects of tourniquet during total knee arthroplasty. A prospective randomised study. J Bone Joint Surg Br 1995;77:250-3.
27. Salam AA, Eyres KS, Cleary J, el-Sayed HH. The use of a tourniquet when plating tibial fractures. J Bone Joint Surg Br 1991;73:86-7.
28. Maffulli N, Testa V, Capasso G. Use of a tourniquet in the internal fixation of fractures of the distal part of the fibula. A prospective, randomized trial. J Bone Joint Surg Am 1993;75:700-3.
29. Tibrewal SB. The pneumatic tourniquet in arthroscopic surgery of the knee. Int Orthop 2001;24:347-9. CrossRef
30. Daruwalla ZJ, Rowan F, Finnegan M, Fennell J, Neligan M. Exsanguinators and tourniquets: do we need to change our practice? Surgeon 2012;10:137-42. CrossRef
31. Oragui E, Parsons A, White T, Longo UG, Khan WS. Tourniquet use in upper limb surgery. Hand (N Y) 2011;6:165-73. CrossRef
32. Estebe JP, Le Naoures A, Chemaly L, Ecoffey C. Tourniquet pain in a volunteer study: effect of changes in cuff width and pressure. Anaesthesia 2000;55:21-6. CrossRef
33. Rajpura A, Somanchi BV, Muir LT. The effect of tourniquet padding on the efficiency of tourniquets of the upper limb. J Bone Joint Surg Br 2007;89:532-4. CrossRef
34. Olivecrona C, Tidermark J, Hamberg P, Ponzer S, Cederfjäll C. Skin protection underneath the pneumatic tourniquet during total knee arthroplasty: a randomized controlled trial of 92 patients. Acta Orthop 2006;77:519-23.
35. Pedowitz RA, Gershuni DH, Fridén J, Garfin SR, Rydevik BL, Hargens AR. Effects of reperfusion intervals on skeletal muscle injury beneath and distal to a pneumatic tourniquet. J Hand Surg Am 1992;17:245-55. CrossRef
36. Cunningham L, McCarthy T, O'Byrne J. A survey of upper and lower limb tourniquet use among Irish orthopaedic surgeons. Ir J Med Sci 2013;182:325-30. CrossRef
37. Sato J, Ishii Y, Noguchi H, Takeda M. Safety and efficacy of a new tourniquet system. BMC Surg 2012;12:17. CrossRef
38. Sadri A, Braithwaite IJ, Abdul-Jabar HB, Sarraf KM. Understanding of intra-operative tourniquets amongst orthopaedic surgeons and theatre staff--a questionnaire study. Ann R Coll Surg Engl 2010;92:243-5. CrossRef