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Original Article

Thigh pain after total knee arthroplasty: Analysis of risk factors

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ABSTRACT

Introduction: Thigh pain may sometimes occur following total knee arthroplasty (TKA). The existence of thigh pain can interfere with postoperative rehabilitation and result in an unpleasant postoperative period. Our aim is to identify the risk factors of post-TKA thigh pain. Although the application of a pneumatic tourniquet is common while performing a TKA, it seems to play a role in the development of post-TKA thigh pain. In addition to the use of a tourniquet, some patient factors may also be associated with the occurrence of thigh pain after TKA. Therefore, we hypothesized that some factors correlated to post-TKA thigh pain exist.
Materials and methods: During 2011–2012, we conducted a prospective cohort study enrolling 347 patients (with 411 cases of primary TKA) in Taipei Veterans General Hospital. There were 283 cases of unilateral and 64 cases of bilateral knee arthroplasty, respectively. All surgeries were performed by a single surgeon. Thigh pain was measured according to the patients' response to the "squeeze test" on the next day after surgery, performed by a single technician. Thigh pain after surgery developed in 33 out of 411 cases of primary TKA. We analyzed the correlation between thigh pain and several possible risk factors, including age, gender, body mass index (BMI), tourniquet time, blood pressure, tourniquet pressure, thigh circumference, and use of patient-controlled analgesia (PCA), using a generalized estimating equation, with SPSS software version 19.0 (SPSS Inc., Chicago, IL, USA).
Results: The study consisted of 77 male (22%) and 270 female (78%) patients. The mean age of the patients was 72.2 years (range, 29–89 years). The mean tourniquet time was 35.3 minutes and mean cuff pressure was 268.8 mmHg. Higher diastolic blood pressure and higher tourniquet pressure correlated to thigh pain, which achieved statistical significance. Age, gender, BMI, PCA use, and tourniquet time were found to have no significant influences on the occurrence of thigh pain.
Discussion: In this study, higher diastolic blood pressure and higher tourniquet pressure were found to have a correlation with thigh pain. Tissue ischemia and reperfusion may explain this finding. Tourniquet time seemed irrelevant, the reason for which might be attributed to the short tourniquet time in our study. In conclusion, factors that influence post-TKA thigh pain exist.

1. Introduction

Development of thigh pain following tourniquet application is a common patient complaint in the early postoperative period following total knee arthroplasty (TKA).[1] The existence of thigh pain can interfere with postoperative rehabilitation and result in an unpleasant postoperative period. Our study found that tourniquet application possibly accounts for a significant proportion of post-TKA thigh pain. A review of the literature showed that, in animal models, the degree of skeletal muscle injury induced beneath and distal to a pneumatic tourniquet was associated with inflation pressure and its duration.[2–5] In human trials, time-dependent hypoxia and acidosis were demonstrated in venous blood taken from distal to the cuff.[6–9] Venous pH fell to 7.0 at 2 hours and resulted in muscle fatigue, ultrastructural changes, and muscle damage. Besides, Worland et al[10] reported a higher incidence (61%) of moderate to severe thigh pain on the 1^{st} day after surgery in patients with a higher tourniquet pressure (TP) (350 mmHg), whereas a lower incidence (only 7%) of thigh pain was reported in patients with a lower TP (mean 230 mmHg). In the current consensus, the tourniquet should be employed at the lowest possible pressure and for the least possible time.[11–13] Some reports describe

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that a systolic blood pressure (SBP) of 30–100 mmHg is enough to prevent the different fluctuations in the blood pressure to maintain control of bleeding during the surgical procedure.[14–16]

However, thigh pain may still develop even when the TKA is performed by a single surgeon, following the same protocol of tourniquet setting as in our daily practice. We hypothesized that in addition to the tourniquet application, some patient factors may be associated with the occurrence of thigh pain after TKA. As only a few studies have discussed the risk factors associated with post-TKA thigh pain, we aimed to identify those risk factors.

2. Materials and methods

A prospective cohort study was performed from June 2011 to June 2012. All patients had advanced knee arthropathy and they underwent primary TKA, performed by a single surgeon, in a single medical center (Taipei Veterans General Hospital, Taipei, Taiwan). Patients having spine disorder and radiculopathy, and those who did not complete the consent form were excluded. We also excluded patients who underwent surgery prior to the weekend to avoid off-duty measurement of thigh pain. A total of 347 patients (with 411 cases of primary TKA) were enrolled in the study. There were 283 cases of unilateral and 64 cases of bilateral knee arthroplasty, respectively.

All patients received a TP of 140 mmHg plus SBP. The tourniquet employed was an ATS 3000 tourniquet system (Zimmer Arthroscopy Systems, Englewood, CO, USA), which was calibrated before use in every case. The tourniquet cuff was 104 cm long and 10.5 cm wide. Five layers of 6-inch cast padding were applied between the skin and the cuff. The circumference of the thigh was measured at the midpoint between the anterior superior iliac spine (ASIS) and the superior pole of the patella. Exsanguination was performed with an Esmarch bandage, and the tourniquet was inflated to the desired pressure according to the SBP recorded by the anesthesiologist prior to the skin incision. We set up the inflation pressure as SBP plus 140 mmHg, which was at least 260 mmHg. The same longitudinal curved incision, as well as a midvastus approach, was employed in all cases. We performed the surgery with an early release of the tourniquet after cement setting, prior to wound closure.

All patients received multimodal pain management, which was started 1 day prior to surgery. COX-2 premedication (Celebrex 200 mg capsule) was given at night, 1 day prior to surgery. After surgery, oral analgesics and cryocompression QID were given. In addition, patients received either IV opiate or patient-controlled analgesia (PCA).

We measured thigh pain according to the patient's response to the "squeeze test" on the first day after surgery, performed by a single technician. The technician would squeeze the middle portion of the thigh gently and observe the patient's response. A guarding, withdrawal, or screaming in response to the squeeze was defined as a positive thigh pain event.

Thigh pain occurred in 33 of the 411 cases of TKAs. We were interested in several possible risk factors, including age, gender, body mass index (BMI), tourniquet time, blood pressure, TP, thigh circumference, and use of PCA. The correlation between thigh pain and possible risk factors were analyzed using a generalized estimating equation, with SPSS software version 19.0 (SPSS Inc., Chicago, IL, USA).

3. Results

A total of 347 patients who underwent unilateral or simultaneous bilateral primary TKAs were included in the study. There were 77 men and 270 women with a mean age of 72 years (range, 29–89 years) (see Table 1 for patient demographics). Among the total 411 cases of TKAs, mean SBP was 127 mmHg (range, 62–200 mmHg), mean diastolic blood pressure (DBP) was 67 mmHg (range, 17–140 mmHg), mean TP was 268 mmHg (range, 260–320 mmHg), and mean tourniquet time was 35 minutes (range, 21–105 mmHg); see Table 2.

Table 1
Patient demographics.

Patient demographics	
Age (y)	72.29 ± 7.57(29–89)[a]
Gender	77 M
	270 F
Diagnosis	OA, RA, SONK, traumatic
Side	205 left/206 right
Height (cm)	153.38 ± 7.49 (136.1–175.3)[a]
Weight (kg)	65.57 ± 11.66 (40.5–115.0)[a]
BMI (kg/m^2)	27.85 ± 4.43 (18.13–45.49)[a]
Thigh circumference (mm)	497.1 ± 56.22 (360–700)[a]

BMI = body mass index; OA = osteoarthritis; RA = rheumatoid arthritis; SD = standard deviation; SONK = spontaneous osteonecrosis of the knee.
[a] Mean ± SD (range).

The 411 cases of TKA were divided into two groups: 33 cases (8%) with thigh pain as Group 1 and the remaining as Group 2. Variables of each group, including body height, body weight, BMI, age, gender, SBP, DBP, TP, tourniquet time, thigh circumference, and use of PCA, were listed in Table 3. Age, body weight, body height, and BMI of the patients were similar in Groups 1 and 2. There was no gender difference between both groups. Patients in Group 1 had a higher SBP than those of Group 2. However, the difference was marginally significant ($p = 0.099$). Patients in Group 1 had higher DBP and TP than those in Group 2. The difference was significant ($p = 0.041$ and 0.009, respectively). There were no statistical differences in tourniquet times in both groups (Group 1: 37.35 ± 8.77 minutes; Group 2: 35.15 ± 7.72 minutes; $p = 0.158$). Group 1 had smaller thigh circumference than Group 2. The difference was insignificant in univariate analysis but achieved statistical significance in multivariate analysis ($p = 0.002$, odds ratio = 0.859). The use of PCA did not reduce the risk of thigh pain ($p = 0.169$).

See Tables 4 and 5 for the results of univariate and multivariate analyses, respectively.

4. Discussion

The pneumatic tourniquet is commonly used in knee surgery and provides a bloodless operative field, improves surgical visualization of the anatomic structures, and reduces operative time. Modern pneumatic tourniquets are designed to minimize the incidence of complications, and prospective randomized clinical trials have shown no significant long-term deleterious effects of using them in extremity surgeries.[17,18]

However, local and systemic complications have been reported as consequences of tourniquet applications.[19–24] The two tissues that are at greatest risk during tourniquet use are nerve and muscle.[8,25,26] Although muscle is more susceptible to ischemic injury

Table 2
Results of mean blood pressure, tourniquet pressure, tourniquet time, and incidence of thigh pain in 411 cases of TKA in 347 patients.

SBP (mmHg)	127.88 ± 22.41 (62–200)
DBP (mmHg)	67.34 ± 14.38 (17–140)
Tourniquet pressure (mmHg)	268.82 ± 13.97 (250–320)
Tourniquet time (min)	35.32 ± 7.81 (21–105)
Thigh pain	33/411 (8.0%)

DBP = diastolic blood pressure; SBP = systolic blood pressure; TKA = total knee arthroplasty.

Table 3
Variables of group 1 (thigh pain) and group 2 (no thigh pain).

Response	Group 1			Group 2		
Variable	Mean ± SD	Min	Max	Mean ± SD	Min	Max
Height (cm)	153.16 ± 8.52	140	175	153.40 ± 7.41	136	175
Weight (kg)	64.90 ± 11.71	45	99	65.62 ± 11.67	40.5	115
BMI (kg/m^2)	27.76 ± 5.12	19.19	40.68	27.86 ± 4.38	18.13	45.49
Age (y)	70.70 ± 6.71	59	84	72.42 ± 7.63	29	89
SBP (mmHg)	135.53 ± 24.42	96	190	127.23 ± 22.14	62	200
DBP (mmHg)	73.37 ± 15.69	48	108	66.83 ± 14.16	17	140
CP	274.24 ± 14.15	250	320	268.35 ± 13.87	126	300
Time	37.35 ± 8.77	22	64	35.15 ± 7.72	17	105
EBL	233.33 ± 185.69	50	850	228.25 ± 145.56	30	900
TC (mm)	478.48 ± 59.65	360	600	498.51 ± 55.81	280	700

BMI = body mass index; DBP = diastolic blood pressure; SBP = systolic blood pressure; TC = thigh circumference.

than any other tissue in the extremity, the most common complication in the clinical setting is neural, including ischemic neuropathy and compressive neurapraxia.[8,25]

Saunders et al[27] have shown fewer electromyographic changes and more rapid clinical recovery of function of quadriceps in patients who had tourniquets applied for shorter times. Other authors believe that postoperative weakness, stiffness, dysthesia, and pain could be related to the neuromuscular damage beneath the tourniquet.[2,15,28] Dobner and Nitz[29] believed that nerve impairment accompanies every tourniquet application. Bruner[30] noted that for tourniquet times close to 60 minutes or more, certain individuals began showing significant adverse effects, whereas for shorter times (20–30 minutes) adverse tissue reactions were not seen. In our study, longer tourniquet time did not increase the risk of thigh pain significantly ($p = 0.584$). Our results contradicted the results of previous studies that demonstrated the time-dependent effect of tourniquet use on tissue injury. The insignificant influence of tourniquet use on thigh pain might be attributed to the fact that the mean tourniquet time was short in our study. The mean tourniquet time was >40 minutes in both groups. The correlation between tourniquet time and thigh pain may be observed in the case of a longer period of tourniquet compression.

Higher TP increased the risk of thigh pain significantly ($p = 0.005$). A strong relationship between TP and thigh pain had been demonstrated in previous studies.[10] Worland et al reported a significantly higher incidence of thigh pain following TKA with higher TP. In their study, 61% patients developed moderate to severe thigh pain on the 1st day after surgery with a TP of 350 mmHg, whereas only 7% patients developed similar pain on the 1st day after surgery with a mean TP of 230 mmHg. In our study, with a mean TP of 268 mmHg, 8% patients had thigh pain on the 1st day after surgery. Patients having thigh pain received a mean TP of 274 mmHg. It showed that even with a pressure >300 mmHg and a tourniquet time >40 minutes, higher TP may still increase the risk of thigh pain. As a goal, the tourniquet should be employed at the lowest possible pressure.

Table 4
Univariate analysis.

Variable	Group 1	Group 2	p
Height (cm)	153.16 ± 8.52	153.40 ± 7.41	0.918
Weight (kg)	64.90 ± 11.71	65.62 ± 11.67	0.787
BMI (kg/m^2)	27.76 ± 5.12	27.86 ± 4.38	0.943
Age (y)	70.70 ± 6.71	72.42 ± 7.63	0.287
Gender (M/F)	8/25	88/290	0.785
SBP (mmHg)	135.53 ± 24.42	127.23 ± 22.14	0.099
DBP (mmHg)	73.37 ± 15.69	66.83 ± 14.16	0.041*
TP	274.24 ± 14.15	268.35 ± 13.87	0.009*
Tourniquet time (min)	37.35 ± 8.77	35.15 ± 7.72	0.158
Thigh circumference (mm)	478.48 ± 59.65	498.51 ± 55.81	0.162
PCA	14	116	0.211

*$p < 0.05$.
BMI = body mass index; DBP = diastolic blood pressure; PCA = patient-controlled analgesia; SBP = systolic blood pressure; TP = tourniquet pressure.

Table 5
Multivariate analysis.

Variable	β	SE (β)	p	Odds ratio
BMI	0.087	0.086	0.310	1.091
Age	−0.032	0.028	0.249	0.968
Gender	0.011	0.590	0.985	1.011
TP	0.050	0.018	0.005*	1.052
Tourniquet time	0.015	0.028	0.584	1.015
PCA	0.652	0.484	0.178	1.919
Thigh circumference	−0.152	0.049	0.002*	0.859

*$p < 0.05$.
BMI = body mass index; PCA = patient-controlled analgesia; TP = tourniquet pressure.

In our study, patient factors such as age, gender, body height, body weight, and BMI had no influence on the risk of thigh pain. The influence of SBP on the risk of thigh pain was marginally significant ($p = 0.099$). Higher DBP increased the risk of thigh pain significantly ($p = 0.041$). A literature review did not provide any information on the relationship between DBP and thigh pain. We presume that higher DBP is related to poorer vessel compliance, which implies poorer tissue reperfusion after tourniquet deflation. Consequently, prolonged tissue ischemia contributed to the development of thigh pain. Further study is needed to clarify this finding.

Smaller thigh circumference increased the risk of thigh pain. The mean thigh circumference was 478 mm in Group 1 and 498 mm in Group 2. The difference in thigh circumference was not statistically significant in univariate analysis ($p = 0.162$) but was statistically significant in multivariate analysis ($p = 0.002$). There might be some confounding factors. Tourniquet inflation produced a local compression effect. The mechanical pressure was a combination of an axial stretching force and a sagittal compressive force. Smaller thigh circumference leads to less soft tissue covering and hence less neuromuscular protection from compression. Our study supported this inference.

The use of PCA did not reduce the risk of thigh pain ($p = 0.169$). Tissue ischemia induces formation of free radicals and inflammation of neuromuscular tissue. Therefore, removal of free radicals and prevention of inflammation are essential for eliminating ischemic pain. As we know, the main analgesic contained in PCA is morphine, which has no anti-inflammatory effect. This might be the reason why PCA use was not effective in the elimination of thigh pain.

Our study has several limitations. First, we failed to demonstrate the tourniquet time as a risk factor of thigh pain. The probable explanation is that the mean tourniquet time in the study was short (>40 minutes). Second, we did not have a tourniquet-free group to compare whether thigh pain still existed without the application of a tourniquet. Further studies on tourniquet-free TKA should be performed. Pain is a very subjective complaint and there is an intraobserver error even when the thigh pain is measured by a single technician.

5. Conclusion

Higher DBP, higher TP, and smaller thigh circumference increase the risk of thigh pain. The effect of tourniquet time on thigh pain was not statistically significant, the reason for which might be attributed to the short tourniquet time in our study.

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