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CONTRIBUTION OF PATIENT CO-MORBIDITIES IN THE DEVELOPMENT OF TOURNIQUET BULLAE FOLLOWING LOWER LIMB SURGERIES.

Medicine

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ABSTRACT

After total knee arthroplasty (TKA), skin blistering remains a notable but rare complication, with multifactorial causes including patient characteristics, surgical techniques, and wound dressings. This study aimed to investigate the influence of patient factors, particularly co-morbidities, on blister formation at the tourniquet site during TKA. **Methodology:** A cohort of 46 consecutive patients underwent lower limb surgeries with a pneumatic tourniquet, and their demographic, clinical, and surgical data were collected for analysis. **Result:** The result revealed that approximately 41.3% of participants experienced blisters, categorized as mild, moderate, or severe. The majority of patients with blisters exhibited a statistically significant difference in age, being younger and having higher values in weight and mid-thigh circumference compared to those without blisters. High systolic blood pressure towards the end of surgery also showed a statistically significant relationship with blister formation. Gender distribution, diagnosis, and the presence of known co-morbidities did not show significance with blister formation. **Conclusion:** This study shows that younger age, higher mid-thigh circumference, increased weight, and higher systolic pressure at the end of surgical procedure predispose to tourniquet blisters in patients undergoing total knee arthroplasty study. It provides valuable insights for clinicians in optimizing patient outcomes and preventing complications associated with skin blistering in TKA procedures.

KEYWORDS

INTRODUCTION

Blisters resulting from tourniquet application are a frequent occurrence in lower limb surgeries, significantly impacting patient outcomes. These fluid-filled lesions, developed due to tourniquet pressure during surgery, pose complications like delayed wound healing, infection, tissue necrosis, and even amputation [1]. The focus of this review is to delve into the significance of comorbidities in tourniquet-induced blisters and their repercussions on patient outcomes. Conditions like hypertension, obesity, diabetes, and cardiovascular diseases are prevalent comorbidities linked to an elevated risk of tourniquet-induced blisters, with potential nerve injuries and muscular damage also noted [1].

Prolonged tourniquet use may lead to "tourniquet pain," accompanied by complications such as nerve and vascular damage, as well as muscle contracture. Historically, patients with sickle cell disease avoided tourniquet use, fearing a sickle cell crisis. However, optimal conditions like sufficient hydration, good oxygenation, warmth and mild hyperventilation have demonstrated that these patients need not be deprived of tourniquet-assisted limb operations [2][3][4][1].

Tourniquet blisters are a common complication following total knee replacement surgery, and while comorbidities and patient factors play a significant role in their development, preventive measures are key to minimizing their occurrence. Tourniquets are commonly employed in TKA to mitigate intraoperative bleeding, ensuring a dry and clean osteotomy surface, minimizing the mixture of bone cement and blood, enhancing surgeon comfort, and aiding implant fixation with bone cement [5, 6]. However, tourniquet usage also entails hidden blood loss, thigh pain, nerve palsy, ischemia, soft tissue damage, thromboembolic complications, poor wound healing, and abnormal tracking of the patellar. Additionally, patient recovery might be impeded due to reduced quadriceps femoris muscle strength, decreased knee range of motion (ROM), and increased pain induced by tourniquet use [7][8].

An assessment of the risks and benefits of tourniquet use is essential before its application. Risks escalate in patients with co-morbidities (e.g., peripheral vascular disease, old age), high tourniquet pressure, and prolonged application [15][16]. Comorbidities significantly influence the occurrence and severity of tourniquet-induced blisters. Conditions like hypertension, obesity, diabetes, and cardiovascular diseases amplify the risk and complications of these blisters. Research indicates that hypertension, prevalent in surgical cohorts, heightens the risk of tourniquet-induced blisters [3]. Diabetes, affecting tissue perfusion, further contributes to blister development. Certain populations, such as children, obese individuals, the elderly, and those with peripheral vascular disease, face a higher likelihood of tourniquet-induced blisters due to compromised circulation and increased skin pressure. The duration and pressure of tourniquet application play crucial roles in blister development. -

Careful assessment of risks and benefits, especially in patients with comorbidities, is imperative. While tourniquet use can be advantageous in specific surgical procedures, the associated risks, particularly in patients with comorbid conditions, must be thoroughly considered [2][3][4].

Total knee arthroplasty (TKA), which stands as a cornerstone in orthopaedic surgery for end-stage knee diseases, is renowned for its efficacy in alleviating pain, enhancing lower limb function, and elevating patients' quality of life [20][25]]. Tourniquets have been integral to TKA procedures since their inception [3, 4]. Hypertension significantly impacts TKA, predisposing patients to cardiovascular accidents and heightening surgical risks. It also elevates the risk of intraoperative bleeding, resulting in poorer prognoses. Despite numerous randomized controlled trials and meta-analyses investigating the effects of tourniquet use during TKA, controversy persists regarding the optimal tourniquet release time and its necessity during surgery [9–11]. Moreover, these studies primarily focused on the general effects of TKA patients, neglecting subgroup analysis for those prone to increased intraoperative blood loss, such as hypertensive individuals.

In Sweden alone, until 2011, tourniquets were employed in around 90% of the 12,048 primary TKAs performed, reflecting widespread adoption [5]. Advocates of tourniquet usage in TKA argue its merits in reducing intraoperative bleeding, facilitating a relatively bloodless surgical field, shortening operative duration, and ensuring optimal cementation for durable implant fixation [6][7][20]. Conversely, detractors raise concerns over potential adverse effects including skin complications, soft-tissue injuries, muscle degradation, ischemia-reperfusion injury contributing to postoperative pain, thigh hematoma, quadriceps weakness, and hindrance to early mobilization and postoperative recovery [8][9]10][19].

Moreover, the advent of enhanced recovery after surgery (ERAS) protocols, notably featuring the widespread administration of tranexamic acid (TXA) as a safe and effective antifibrinolytic agent perioperatively, alongside controlled hypotension techniques during surgery, has markedly curtailed total blood loss and intraoperative bleeding, thereby offering a bloodless operative milieu in TKA [11][12] [13].

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PATIENTS AND METHODS

Forty-six consecutive patients undergoing Total Knee Replacement were recruited into this study between 2019 and 2022. Their biodata and comorbidities, like hypertension, diabetes, and obesity, were taken. They had their surgeries under a pneumatic tourniquet applied at an average of 28cm above the knee joint.

The tourniquet was applied after giving epidural anaesthesia, and the patient lay supine on the theatre table.

The pneumatic tourniquet pressures were set randomly between 280mmHg and 360mmHg, depending on the size of the thigh.

The slenderer patients had their tourniquet pressure set at lower levels, while the obese patients received a higher range of pressures.

All the tourniquet cuffs were applied over a cushion of soft band wrapped at the point of application.

The pneumatic tourniquet was inflated to the set pressures.

The tourniquet sites were checked for blisters immediately after surgery, 1 hour and 24 hours after surgery.

These were measured according to their sizes.

The findings were analyzed using several statistical tools.

RESULT

Table 1 Socio-Demographics

	Mean (SD) Median (IQR) N	**Range %**
Age	64.37 ± 9.1	26.0-83.0
Weight (kg)	81.0 (72.25-103.0)	56.0-145.0
Mid-thigh circumference	60.0 (56.0-72.0)	53.0-102.0
Gender		
Female	42	91.3
Male	4	8.7
Occupation		
Business	17	37
Retired	12	26.1
Civil Servant	6	13
None	11	23.9
Religion		
Christian	46	100

Table 2 Surgical And Clinical Characteristics

	Frequency (n)	**Percentage (%)**
DIAGNOSIS		
Severe Right Knee Osteo Arthritis	23	50
Severe Left Knee Osteo Arthritis	20	43.5
Failed Left TKR	1	2.2
Failed Left Infected TKR	1	2.2
Failed Primary Left TKR	1	2.2
PROCEDURE		
Right TKR	23	50
Left TKR	20	43.5
Left Revision TKR	1	2.2
Removal Of Implant, Debridement + Washout + Implantation of Spacer	1	2.2
Revision TKR	1	2.2
PRESENCE OF CO-MORBIDITIES		
Known Hypertensive		
Yes	36	78.3
No	10	21.7
Known Diabetic		
No	38	82.6
Yes	8	17.4
Diastolic Blood Pressure (DBP)		
DBP (Before Surgery)	78.76 ± 11.07	57.0-106.0
DBP (Middle of Surgery)	79.39 ± 12.78	60.0-112.0
DBP (End of Surgery)	78.89 ± 9.68	58.0-100.0
Systolic Blood Pressure (SBP)		
SBP (Before Surgery)	130.22 ± 18.74	87.0-165.0
SBP (Middle of Surgery)	130.59 ± 28.24	13.0-194.0
SBP (End of Surgery)	131.87 ± 16.96	82.0-162.0
BLISTERS		
Presence Of Blisters		
No	27	58.7
Yes	19	41.3
Mild Blisters (Less than 1cm)		
No	32	69.6
Yes	14	30.4
Moderate Blisters (1 to 5cm)		
No	42	91.3
Yes	4	8.7
Severe Blisters (Greater than 5cm)		
No	45	97.8
Yes	1	2.2
Blisters occurring immediately after procedure		
No	28	60.9
Yes	18	39.1
Blisters occurring one hour after procedure		
No	45	97.8
Yes	1	2.2
Blisters occurring 24 hours after procedure		
No	37	80.4
Yes	9	19.6
Blister requiring dressing		
No	46	100
MANAGEMENT PROTOCOL		
Patient on antibiotics		
Yes	44	95.7
No	2	4.3
On antibiotics before surgery		
No	36	78.3
Yes	10	21.7
On antibiotics after surgery		
Yes	45	97.8
No	1	2.2

Regarding the management protocol, the use of antibiotics, both before and after surgery, did not show a statistically significant association with blister presence.

Table 3 Factors Associated With Presence Of Blisters

	No (n = 27)	**Yes (n = 19)**	**p-value**
Age	66.59 ± 6.69	61.21 ± 11.16	0.047**
Weight	74.0 (68.5-82.5)	103.0 (84.5-125.5)	0.0001**
Mid-thigh circumference	58.0 (55.0-60.75)	72.0 (65.0-86.0)	0.0001**
Gender			
Female	24 (88.9)	18 (94.7)	
Male	3 (11.1)	1 (5.3)	0.872
Diagnosis			
Failed left infected TKR	0 (0.0)	1 (5.3)	
Failed left TKR	0 (0.0)	1 (5.3)	0.322
Failed primary left TKR	0 (0.0)	1 (5.3)	
Severe left knee osteo arthritis	12 (44.4)	8 (42.1)	
Severe right knee osteo arthritis	15 (55.6)	8 (42.1)	
Known Hypertensive			
No	8 (29.6)	2 (10.5)	
Yes	19 (70.4)	17 (89.5)	0.237
Known Diabetic			
No	23 (85.2)	15 (78.9)	
Yes	4 (14.8)	4 (21.1)	0.877
Diastolic Blood Pressure (DBP)			

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DBP (Before Surgery)	77.04 ± 10.75	81.21 ¬± 11.34	0.212
DBP (Middle of Surgery)	76.37 ± 11.88	83.68 ¬± 13.09	0.055
DBP (End of Surgery)	77.26 ± 10.08	81.21 ¬± 8.83	0.176
Systolic Blood Pressure (SBP)			
SBP (Before Surgery)	126.22 ± 19.6	135.89 ¬± 16.28	0.085
SBP (Middle of Surgery)	128.04 ± 20.74	134.21 ¬± 36.73	0.472
SBP (End of Surgery)	129.0 (118.0-138.5)	140.0 (134.5-146.0)	0.014**
MANAGEMENT PROTOCOL			
On antibiotics			
No	2 (7.4)	0 (0.0)	
Yes	25 (92.6)	19 (100.0)	0.632
On antibiotics before surgery			
No	22 (81.5)	14 (73.7)	
Yes	5 (18.5)	5 (26.3)	0.788
On antibiotics after surgery			
No	1 (3.7)	0 (0.0)	
Yes	26 (96.3)	19 (100.0)	0.999
** Statistically significant			

Table 4 Logistic Regression Analysis To Determine The Predictive Variables Of Blisters Among Patient Who Underwent Knee Arthroplasty

Predictive Variables	Odds Ratio	p-value	95% Confidence Interval (CI)
Age	0.922	0.0707	0.845 - 1.007
Weight (kg)	1.068	0.0013**	1.026 - 1.111
Mid-thigh circumference	1.151	0.0015**	1.056 - 1.256
Known Hypertensive			
No (ref)	-	-	-
Yes	3.579	0.1373	0.666 - 19.241
Known Diabetic			
No (ref)	-	-	-
Yes	1.533	0.5842	0.332 - 7.088
SBP (End of Surgery)	1.04	0.0584	0.999 - 1.084
** Statistically significant			

Table 5 Multivariate Logistic Regression Analysis To Determine The Predictive Variables Of Blisters Among Patient Who Underwent Knee Arthroplasty

	Odds Ratio	p-value	95% CI
Age	0.909	0.0953	0.813 - 1.017
Mid-thigh circumference	1.196	0.0024**	1.065 - 1.342
Known Diabetic			
No (ref)	-	-	-
Yes	0.411	0.5158	0.028 - 5.993
Known Hypertensive			
No (ref)	-	-	-
Yes	6.107	0.2157	0.348 - 107.097
SBP (End of Surgery)	1.075	0.0468**	1.001 - 1.154
** Statistically significant			

DISCUSSION

The study comprised 46 participants undergoing Total Knee Arthroplasty (TKA) and other knee surgeries with a mean age of 64.37 years (SD ± 9.1) and a diverse age range from 26.0 to 83.0 years. Participants exhibited variability in weight (mean 81.0 kg, IQR 72.25-103.0 kg) and mid-thigh circumference (mean 60.0 cm, IQR 56.0-72.0 cm). Gender distribution is skewed towards females, constituting 91.3% of the sample. The majority were engaged in business (37%), followed by retirees (26.1%), civil servants (13%), and individuals with no specified occupation (23.9%). All participants identified as Christian (100%). Surgical and Clinical Characteristics: Diagnosis: The participants presented with diverse knee conditions, with 50% having severe right knee osteoarthritis, 43.5% with severe left knee osteoarthritis, and smaller proportions with failed left TKR, failed left infected TKR, and failed primary left TKR. Procedure: Surgical interventions included 50% undergoing right TKR, 43.5% left TKR, and smaller percentages for left revision TKR, removal of implant with debridement and washout, and revision TKR. Presence of Co-Morbidities: The majority of participants (78.3%) were known hypertensive while 17.4% of participants had a known diabetic condition. Diastolic blood pressure (DBP) ranged from 57.0 to 106.0 before surgery, 60.0 to 112.0 in the middle of surgery, and 58.0 to 100.0 at the end of surgery. Similar variations were also observed for Systolic blood pressure (SBP) which ranged from 87.0 to 165.0 before surgery, 13.0 to 194.0 in the middle of surgery, and 82.0 to 162.0 at the end of surgery. Blisters: Approximately 41.3% of participants experienced blisters, categorized as mild (30.4%), moderate (8.7%), and severe (2.2%). Blisters occurred immediately after the procedure in 39.1% of cases, with 2.2% occurring one hour after the procedure and 19.6% occurring 24 hours after the procedure. Most participants were on antibiotics (95.7%), with 21.7% on antibiotics before surgery and 97.8% on antibiotics after surgery. Only 4.3% were not on antibiotics. The investigation into factors associated with blisters following Total Knee Arthroplasty (TKA) revealed significant associations across various parameters. Participants with blisters (n=19) exhibited a statistically significant difference in age, being younger (61.21 ± 11.16 years), compared to those without blisters (n=27) with a mean age of 66.59 ± 6.69 years (p=0.047). Weight and mid-thigh circumference also demonstrated significant associations with blister formation (p=0.0001), with higher values observed in the blister group (Weight: 103.0, IQR: 84.5-125.5; Mid-thigh circumference: 72.0, IQR: 65.0-86.0) compared to the non-blister group (Weight: 74.0, IQR: 68.5-82.5; Mid-thigh circumference: 58.0, IQR: 55.0-60.75). Gender distribution, diagnosis, and the presence of known co-morbidities were analysed. No statistically significant differences were observed in gender distribution between the blister and non-blister groups. The diagnosis of failed left infected TKR, failed left TKR, and failed primary left TKR showed no significant association with blister formation. However, participants with severe left knee osteoarthritis (42.1%) and severe right knee osteoarthritis (42.1%) demonstrated a slightly higher blister incidence than other diagnoses. Known hypertensive individuals were more prevalent in the blister group (89.5%) than in the non-blister group (70.4%), though this difference did not reach statistical significance (p=0.237). Known diabetic status did not show a significant association with blister formation.[23][24] This is contrary to the findings by Kohler et al., Drolet and colleagues and Pacquette et al., showing a higher risk of complication with diabetics but align with them on findings with hypetension.[24][25][26][29] Analysis of blood pressure parameters revealed no statistically significant differences in diastolic blood pressure (DBP) at different surgical phases between the blister and non-blister groups. However, systolic blood pressure (SBP) at the end of surgery was significantly higher in the blister group (140.0, IQR: 134.5-146.0) compared to the non-blister group (129.0, IQR: 118.0-138.5), indicating a potential association with blister formation (p=0.014). This partially conforms with the finding by Kohler et al, and Pacquette et al, showing that hypertension contributes significantly to post operate complications following tourniquet use.[25][26] Regarding the management protocol, the use of antibiotics, both before and after surgery, did not show a statistically significant association with blister presence. In the univariate logistic regression analysis aimed at discerning predictive variables associated with the occurrence of blisters following Knee Arthroplasty, several factors were scrutinised. A significant positive association was identified between weight and blister formation (Odds Ratio: 1.068, p=0.0013**). This suggests that an increase in weight is associated with an elevated likelihood of developing blisters. Similarly, mid-thigh circumference demonstrated statistical significance, indicating that a larger mid-thigh circumference is associated with a higher likelihood of blister occurrence (Odds Ratio: 1.151, p=0.0015**). Systolic blood pressure at the end of surgery approached significance (Odds Ratio: 1.04, p=0.0584), indicating a trend towards increased odds of blister formation with higher systolic blood pressure at this stage. The remaining variables, including age, known hypertensive status, known diabetic status, and SBP at other stages of surgery, did not reach statistical significance in predicting blister formation. Conducting a multivariate logistic regression analysis to discern predictive variables amidst potential confounding factors in the context of blister development following Knee Arthroplasty yielded discerning insights. A positive association was observed between mid-thigh circumference and blister formation (Odds Ratio: 1.196, p=0.0024). This underscores the significance of considering anatomical dimensions, particularly mid-thigh circumference, as a predictive factor influencing the likelihood of post-arthroplasty blister occurrence. Systolic blood pressure at the conclusion of the surgical procedure stood out as another critical predictor (Odds Ratio: 1.075, p=0.0468). This suggests a potential role for hemodynamic factors at a specific procedural phase in contributing to blister formation, emphasising the need for nuanced monitoring and management. [25][28]

CONCLUSION:

This study shows that younger age, higher mid-thigh circumference, obesity, and higher systolic pressure at the end of surgical procedure predispose to tourniquet blisters in patients undergoing total knee arthroplasty. It provides valuable insights for clinicians in optimizing patient outcomes and preventing complications associated with skin blistering in lower limb procedure3s procedures.

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