Blood loss and knee function after unicompartment knee arthroplasty(UKA) without tourniquet

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Research article

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Abstract

Background

The characteristics of blood loss and knee function after unicompartment knee arthroplasty(UKA) remains unclear. Utilization of tourniquet is considered to compromise the outcome of knee arthroplasty. This study aims to evaluate the hidden blood loss and function restoration of UKA without tourniquet by comparing with total knee arthroplasty(TKA).

Methods

In this retrospective study, a total of 112 patients were included from August 2017 to October 2018. Both the UKA group (n = 56) and the TKA group (n = 56) underwent procedure without utilization of tourniquet during the whole process. The gender, age, body mass index, American Society of Anesthesiologists score, Kellgren-Lawrence grade, preioperative Hb, and volume of hidden blood loss (HBL) were recorded and analysed. Knee function was assessed at 3 month and 12 month after procedure by using HSS score.

Result

The mean volume of HBL was significant lower in UKA group (324.23ml ± 147.05, 864.82ml ± 206.37, P = 0.001). The HSS score was higher in UKA group 3 month after procedure (88.16 ± 5.57, 83.04 ± 4.88, P = 0.033). No HBL difference was observed in either groups in terms of gender nor age. Hb level dropped to the bottom at the 4th day postoperatively. No correlation was observed between HBL and knee function.

Conclusion

Without utilization of tourniquet, the HBL could not be ignored in UKA though it is much less than TKA, and the knee function was not compromised by it.

Trial registration

Current trial ISRCTN85133278 (Retrospectively registered on 06 April 2020).

Background

Postoperative blood loss is discussed for years as a common complication after hip fracture and arthroplasty. Studies are focused on it because the postoperative hemoglobin (Hb) concentration is prone to decrease much more than anticipation in these procedures, and it compromises the clinical outcome. Such kind of blood loss is invisible if there is no tube drainage, so it could be named as hidden blood loss(HBL). In terms of knee arthroplasty, blood loss is considered to be associated with extensive osteotomy, soft tissue release, tourniquets, and thromboprophylaxis. The volume of HBL could reach to 1000–2000 ml after total knee arthroplasty (TKA) in literatures[1, 2]. The causes of HBL are still

debatable, but there are some well-accepted explanations including hemolysis [3], which is considered as a result of tourniquet. Besides, significant residual blood permeating into joint and soft tissues would be another main reason[4].

UKA is usually performed by a minimal invasive approach. It has potential advantages like less injury, shorter operation time, and faster recovery compared with TKA. However, we found the total blood loss volume in UKA was more than intraoperative bleeding even if the tourniquet doesn't stand in the way, and the postoperative drop of Hb could not be ignored although no transfusion was required. To the best of our knowledge, there was no literature talking about the blood loss after UKA without tourniquet.

The relationship of HBL and knee function after knee arthroplasty is unclear. The limited studies published told us less HBL may play a role in better outcome after TKA as HBL was correlated with limb swelling[5]. The correlation of HBL and knee function after UKA is in need of further research.

The hypotheses of this study were that (1) there is a certain amount of HBL after UKA without tourniquet; (2) UKA without tourniquet results in less HBL compared with TKA; (3) UKA without tourniquet enjoys a better outcome than TKA.

Methods

Patients

Patients who had undergone UKA or TKA between August 2017 and October 2018 were selected for this retrospective comparison. The inclusion criteria were primary UKA or TKA, the Kellgren-Lawrence (KL) grade of medial knee osteoarthritis meet to grade Ⅲ. The exclusion criteria were preoperative abnormality in coagulation function, hematonosis history, postoperative poor general situation, more than 2000ml per day in fluid infusion, simultaneous bilateral UKA or TKA, and UKA or TKA secondary to a failed arthroplasty procedure.

The study group (UKA) comprised 56 patients with a diagnosis of medial compartment osteoarthritis. The control group (TKA) comprised 56 patients with a diagnosis of medial compartment osteoarthritis, who could be combined with mild osteoarthritis of the other two compartments. Both groups were comparable with respect to gender, age, body mass index(BMI), American Society of Anesthesiologists(ASA) score, severity of arthritis, and preoperative Hb(Table 1).

All the procedures were done by one senior arthroplasty doctor and his medical team. All patients received general anesthesia, and all cases were performed without tourniquet. The application of pressure bandaging was used after wound closure without drains. Autologous blood transfusion(ABT) was used in all procedures (Autolog Medtronic).

Table 1. Demographics and baseline measurements

	UKA	TKA	P value
Sex F/M	21/35	23/33	0.699
Age	63.4±5.9	65.1±7.5	0.373
BMI	25.7±3.9	26.4±4.3	0.614
ASA score 1/2	17/39	15/41	0.676
Kellgren-Lawrence grading			
□	56	56	1.000
preoperative Hb, mg/dl	12.4±2.1	12.9±2.7	0.266

Surgical methods

In UKA group a minimally invasive medial approach was employed. The length of the incision was approximately 8cm. All the bony cuts were done according to a standard process by using conventional jigs with very limited soft tissue dissection on the medial side. A cemented Biomet Oxford □ system(Biomet, Warsaw, US) was implanted in all the patients of the group. No tranexamic acid was used perioperatively.

In TKA group a standard medial parapatellar approach was employed. An extramedullary jig was used on the tibial side while an intramedullary jig was used on the femoral side. The medullary canal was closed with a bone plug fashioned from distal femoral bone cut. There was no patellar resurfacing performed in procedure. A cemented GENESIS II system(Smith & Nephew Inc.Memphis, TN, USA)was implanted in all the patients of the group.

Follow-up assessment

The postoperative rehabilitation regime was identical for both groups. Oral thromboprophylaxis (Rivaroxaban) was given 12 hours postoperatively and continued for 35 days. Physical therapy including active isometric quadriceps, initiative straight leg raises, range of motion exercises, and partial weight bearing was encouraged from the 2nd postoperative day. The Hb and the haematocrit (Hct) levels were measured for all the patients pre- and post-operatively. All patients had a full blood count on the 2nd day, 4th day, 6th day, and 8th day postoperatively. The transfusion trigger was defined as a hemoglobin level of less than 80 g/L and in those who presented with symptoms of anemia. The function of knee was assessed according to HSS score 3 months and 12 months postoperatively. The occurrence of complications was recorded until the final follow-up.

Calculation of hidden blood loss

The HBL was calculated by using the Gross formula[6]. The patient's blood volume(PBV)=kl × height $(m)^3$ + k2 × weight (kg) + k3 , where k is constant, whose values are, kl = 0.3669, k2 = 0.03219, k3 = 0.6041 for

men; kl = 0.3561, k2 = 0.03308, k3 = 0.1833 for women.

Multiplying the PBV by the Hct gave the total red cell volume. The different blood loss variables were calculated as follows:

Red blood cell(RBC) loss= PBV×(preoperative Hct – postoperative Hct)

Total blood loss = RBC loss + intraoperative blood transfusion(Autologous transfusion included)+ postoperative blood transfusion

Hidden blood loss = Total blood loss - intraoperative blood loss

Intraoperative blood loss was assessed by weighing sponges.

Statistical analysis

Statistical analysis was performed using SPSS version 17.0 software (SPSS, Chicago, IL, USA). Continuous data were expressed as means (± standard deviation). Chi-square test was used for comparing of count data. Student t-test was used for comparing of continuous variables. Pearson's correlation analysis was used to test the correlation of continuous variables. The level of significance was set at $P < 0.05$.

Result

Comparison of HBL and HSS scores between two groups

The mean volume of HBL was (324.23±147.05)ml in UKA group, and (864.82±206.37)ml in TKA group. The difference was significant (t=6.126 P=0.001). The mean HSS score was 88.16±5.57 in UKA group, and 83.04±4.88 in TKA group 3 month after procedure. The difference was significant (t=2.157 P=0.033). The mean HSS score was 88.45±6.07 in UKA group, and 86.84±4.51 in TKA group 12 month after procedure. The difference was not significant (t=0.759 P=0.439).(Table 2)

Table 2. HSS score

	UKA	TKA	P value
Preoperation	60.42±7.37	58.92±5.23	0.512
Postoperation (3 month)	88.16±5.57	83.04±4.88	0.033
Postoperation (12 month)	88.45±6.07	86.84±4.51	0.439

Comparison of HBL in gender/age

The mean volume of HBL in different gender and different age are presented in Table 3. There was no significant difference on HBL between male and female in either groups. There was no significant difference on HBL between patients younger than 70 years old and patients elder than 70 years old in either groups.

Table 3. HBL in gender/age

	UKA	TKA
Male	315.63±97.04	873.17±188.75
Female	332.82±113.56	853.79±211.02
P value	0.295	0.108
50-70yrs	333.63±108.69	869.19±237.29
>70yrs	319.57±95.92	850.54±181.46
P value	0.208	0.137

Correlation between HBL and BMI / HSS score

At 3 month after procedure, no correlation was found between HBL and BMI(P=0.702), or between HBL and HSS score(P=0.074) in UKA group. No correlation was found between HBL and BMI(P=0.091) or between HBL and HSS score(P=0.082) in TKA group.

Hb level in different timing after procedure

The mean Hb levels are presented in Table 4. There was significant difference between two groups on the 2nd day, 4th day, 6th day ,8^{th}day postoperatively.

Table 4.Hb levels in different timing after procedure

	UKA (g/dl)	TKA (g/dl)	P value
Day 2	10.9±1.1	9.7±1.8	0.017
Day 4	9.0±1.7	8.5±1.8	0.009
Day 6	9.1±2.1	8.2±1.9	0.011
Day 8	9.3±1.7	8.1±2.0	0.020

Transfusion and complications

There were 2 cases in TKA group accepted transtusion and none in UKA Group. There was a case of polyethylene insert dislocation 5 months after UKA, and a case of infection 3 months after TKA.

Discussion

Previous discuss of HBL was addressed in hip surgery and TKA. The idea that TKA results in significant HBL was reported in literatures[7, 8], and there were complications such as hypotension, acute myocardial infarction caused by acute postoperative anemia[6]. Furthermore, homologous transfusion consequent on HBL could increase a potential periprosthetic infection risk[9]. On the other hand, the literatures about blood loss of UKA was limited. Schwab et al. compared 105 UKA cases with 105 TKA cases and concluded that Hb drops more sharply in TKA with more HBL [10]. Yang et al. reported a similar result via a prospectively matched study of 100 patients[11]. Ann reported lower blood loss in bilateral simultaneous UKA compared with unilateral TKA[12]. However, the cause of HBL in UKA was not well explained. UKA does have some potential advantages such as smaller incision, less injury, shorter operation time compared with TKA, but invasive process is inevitable such as osteotomy, femoral canal opening, some synovectomy. Besides, the utilization of tourniquet is considered as a main risk factor of HBL[13].

Tourniquet is preferred by most of joint surgeons during arthroplasty. Theoretically, the HBL or drop of Hb are not supposed to be significant when the procedure is performed with tourniquet. However, the postoperative blood loss is much more than expected, sometimes over 2000ml[14]. Hemolysis is considered as a main factor for this scenario. The vein of involved extremity dilate rapidly after tourniquet release, which results in venous stasis and triggers the process of fibrinolytic reaction[3, 4]. The impact of tourniquet to blood loss is still controversial. In this study we removed the impact from tourniquet and observed significant less HBL in UKA compared with TKA, but it could not be ignored by any means. This finding may be related to the technique of controlled hypotension employed by our anesthesiologist in procedure. The blood pressure maintained at a low level for improving visualization of structures during

the procedure, but it rose as a response to pain after patient's recovery which would invite bleeding. Besides, the absence of tranexamic acid also played a role[15, 16].

Debates exist on gender being correlated to HBL. Prasad et al.reported that males suffer more HBL[1], while some other literatures demonstrated that there was no significant difference of HBL in genders [2, 6]. Our study found that HBL has no significant difference between genders in either UKA group or TKA group. It is controversial as well about the correlation between HBL and age. Yoshihara et al.took oldness as a risk factor of HBL due to the poor capacity of Hb reserve of old patients. They are prone to suffering more HBL and are more vulnerable to blood loss[17]. Durasek et al.reported an opposite result in a prospective randomized study on 184 patients, they found older patients had lower hemoglobin level before blood transfusion and received greater volumes of blood transfusion, but the difference was not statistically significant[2]. In our study, we also found the difference on HBL between different age groups was not significant. In Frisch et al.'s study[18], BMI played a role in HBL and postoperative transfusion, they suspected that vascular wall sclerosis could be a factor. The correlation between HBL and BMI was not significant in our study. However, this finding may be due to the small sample size of our study, with most patients' BMI ranging from 18 to 26 kg/m^2, and the patients with a high BMI could not be evaluated accurately.

Preoperative Hb is usually stable, while postoperative Hb varies widely. Schwab et al.found that Hb dropped to bottom around the 4th day after TKA or UKA[10]. Prasad et al. reported the reduction of Hb usually started from one week after TKA[1]. In terms of these findings, our study bracketed the first 8 days post operation as an observing period. We picked the 2nd day, the 4th day, the 6th day, and the 8th day post operation as time nodes to see the variation of Hb, and found that Hb level in UKA was higher than it was in TKA at all the four time nodes. Moreover, in UKA group the Hb level reached to the bottom at the 4th day postoperatively and begun to rebound after that, while in TKA group the Hb kept dropping during observing period. We consider that the minimal invasive procedure could benefit circulating blood volume and relieve the impact to patients.

Autologous blood transfusion was performed on all the patients of this study as the absence of tourniquet. The purpose of ABT is for the reduction of blood volume. Li et al. demonstrated that ABT could reduce the risk of allogenic blood transfusion[19]. However, ABT itself is a possible risk factor of HBL in the study of Xu et al. They found HBL was significantly less in the TKA group without ABT[20]. There was no case required allogenic blood transfusion in UKA group. Although in 2 cases the Hct dropped below 0.28L/L postoperatively but the Hb maintained beyond 80 g/L. Allogenic blood transfusion was performed on 2 female cases in TKA of our study. Brown et al. considered the very low rate of transfusion in UKA can be related to the sex distribution[21]. They explained that males took up a higer proportion in UKA than in TKA, and males' higher level of preoperative blood volume and Hb contributed to low rate of transfusion. The difference of sex distribution between UKA group and TKA group was not significant in our study, and the transfusion rate of TKA group was even higher than 2% which was reported in Schwab et al.'s study[10], so we hold the opinion that lower transfusion rate is more affected by surgery rather than gender or ABT.

As we know, the relationship of HBL and knee function is rarely mentioned in literatures. The hypoperfusion in operation area caused by HBL would compromise soft tissue healing, and it is associated with lower limb swelling[6]. However,it is still unclear that if HBL would compromise postoperative knee function. Budde et al. found better knee function in patients with less intra- and post-operative blood loss[22]. They compared 34 patients undergoing standard TKA with 34 patients receiving a kind of hemostatic after TKA, and found a better function outcome in the hemostatic group. In Joyce et al.'s study, the relationship of blood loss and joint function was not significant[23], and they concluded that using the investigated haemostatic agent regularly was not necessary. UKA is believed having better knee function than TKA at early follow-up[21]. Our study supports this idea when we found the HSS score is significantly higher in UKA group at 3 month after procedure. However, the difference tended to disappear at 12 months postoperatively. Meanwhile, we found that the correlation of HBL and knee function has no clinical significance in UKA group. It may be due to the fact that the reduction of blood loss in UKA could be achieved by individual compensation without allogenic blood transfusion. And it also reminded us that the perioperative blood loss had limited influence on the outcome of UKA.

There were some limitations in our study. First, the correlation between BMI and HBL was not very convincing as an insufficient observation of the patients with BMI out of the interval 18–26 kg/m^2. Second, the continuous observation of Hb level after surgery was too short to obtain a full pattern of Hb variation. Third, all the procedures in our study were performed in one institution by one surgeon who followed a standard protocol, hence, some other risk factors of HBL such as the use of thromboprophylaxis, the use of drain were not included in the analysis.

Conclusion

Though much less than the case after TKA, the HBL (without utilization of tourniquet) after UKA could not be ignored. The HBL may not be affected by BMI, gender nor age, and the postoperative knee function would not be compromised by HBL. The knee function was better in UKA at a very early stage after procedure.

Declarations

Competing interests

The authors declare that they have no competing interests.

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Ethics approval and consent to participate

The study has gotten approval from Medical Ethics Committee of the first people's hospital of Huzhou. The approval number is 2019035. Consent to participate is not applicable for this retrospective study.

Consent for publication

I have obtained consents to publish from the participants.

Availability of data and materials

The datasets during and/or analyzed during the current study are available from the corresponding author on reasonable request.

Authors' contributions

ZZF designed the study. WLD, WD and MJK operated on the Patients. ZZF, ZJM performed data acquisition and follow-up. ZZF, MJK, and ZJM performed data analysis and interpretation. ZZF prepared the manuscript. All authors read and approved the final manuscript.

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