A Retrospective Analysis of Hemostatic Techniques in Primary Total Knee Arthroplasty: Traditional Electrocautery, Bipolar Sealer, and Argon Beam Coagulation

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Abstract

In this retrospective cohort study of 280 primary total knee arthroplasties, clinical outcomes relevant to hemostasis were compared by electrocautery type: traditional electrocautery (TE), bipolar sealer (BS), and argon beam coagulation (ABC).

Age, sex, and preoperative diagnosis were not significantly different among the TE, BS, and ABC cohorts. The 3 hemostasis systems were statistically equivalent with respect to estimated blood loss. Wound drainage during the first 48 hours after surgery was equivalent between the BS and ABC cohorts but less for the TE cohort. Transfusion requirements were not significantly different among the cohorts. The 3 hemostasis systems were statistically equivalent with respect to mean change in hemoglobin level during the early postoperative period (levels were measured on postoperative day 1 and on discharge).

As BS and ABC are clinically equivalent to TE, their increased cost may not be justified.

Total knee arthroplasty (TKA) is a reliable and successful treatment for end-stage degenerative joint disease of the knee. Given the reproducibility of its generally excellent outcomes, TKA is increasingly being performed.[1] However, the potential complications of this procedure can be devastating.[2-4] The arthroplasty literature has shed light on the detrimental effects of postoperative blood loss and anemia.[5,6] In addition, the increase in transfusion burden among patients is not without risk.[7] Given these concerns, surgeons have been tasked with determining the ideal methods for minimizing blood transfusions and postoperative hematomas and anemia. Several strategies have been described.[8-11] Hemostasis can be achieved with use of intravenous medications, intra-articular agents, or electrocautery devices. Electrocautery technologies include traditional electrocautery (TE), saline-coupled bipolar sealer (BS), and argon beam coagulation (ABC). There is controversy as to whether outcomes are better with one hemostasis method over another and whether these methods are worth the additional cost.

In traditional (Bovie) electrocautery, a unipolar device delivers an electrical current to tissues through a pencil-like instrument. Intraoperative tissue temperatures can exceed 400°C.[12] In BS, radiofrequency energy is delivered through a saline medium, which increases the contact area, acts as an electrode, and maintains a cooler environment during electrocautery. Proposed advantages are reduced tissue destruction and absence of smoke.[12] There is evidence both for[10,12-16] and against[17-20] use of BS in total joint arthroplasty. ABC, a novel hemostasis method, has been studied in the context of orthopedics[21,22] but not TKA specifically. ABC establishes a monopolar electric circuit between a handheld device and the target tissues by channeling electrons through ionized argon gas. Hemostasis is achieved through thermal coagulation. Tissue penetration can be adjusted by changing power, probe-to-target distance, and duration of use.[23]

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We conducted a study to assess the efficacy of all 3 electrocautery methods during TKA. We hypothesized the 3 methods would be clinically equivalent with respect to estimated blood loss (EBL), 48-hour wound drainage, operative time, and change from preoperative hemoglobin (Hb) level.

Methods

We conducted a retrospective cohort study of consecutive primary TKAs performed by Dr. Levine between October 2010 and November 2011. Patients were identified by querying an internal database. Exclusion criteria were prior ipsilateral open knee procedure, prior fracture, nonuse of our standard hemostatic protocol, and either tourniquet time under 40 minutes or intraoperative documentation of tourniquet failure. As only 9 patients were initially identified for the TE cohort, the same database was used to add 32 patients treated between April 2009 and October 2009 (before our institution began using BS and ABC).

Clinical charts were reviewed, and baseline demographics (age, body mass index [BMI], preoperative Hb level) were abstracted, as were outcome metrics (EBL, 48-hour wound drainage, operative time, postoperative transfusions, adverse events (AEs) before discharge, and change in Hb level from before surgery to after surgery, in recovery room and on discharge). Statistical analyses were performed with JMP Version 10.0.0 (SAS Institute). Given the hypothesis that the 3 hemostasis methods would be clinically equivalent, 2 one-sided tests (TOSTs) of equivalence were performed with an α of 0.05. With TOST, the traditional null and alternative hypotheses are reversed; thus, $P < .05$ identifies statistical equivalence. The advantage of this study design is that equivalence can be identified, whereas traditional study designs can identify only a lack of statistical difference.[24] We used our consensus opinions to set clinical insignificance thresholds for EBL (150 mL), wound drainage (150 mL), decrease from postoperative Hb level (1 g/dL), and operative time (10 minutes). Patients who received a blood transfusion were subsequently excluded from analysis in order to avoid skewing Hb-level depreciation calculations. Analysis of variance (ANOVA) and χ^2 tests were used to compare preoperative variables, transfusion requirements, hospital length of stay, and AE rates by hemostasis type.

Cautery Technique

In all cases, TE was used for surgical dissection, which followed a standard midvastus approach. Then, for meniscal excision, the capsule and meniscal attachment sites were treated with TE, BS, or ABC. During cement hardening, an available supplemental cautery option was used to achieve hemostasis of the suprapatellar fat pad and visible meniscal attachment sites. All other aspects of the procedure and the postoperative protocols—including the anticoagulation and rapid rehabilitation (early ambulation and therapy) protocols—were similar for all patients. The standard anticoagulation protocol was to use low-molecular-weight heparin, unless contraindicated. Tranexamic acid was not used at our institution during the study period.

Results

For the study period, 280 cases (41 TE, 203 BS, 36 ABC) met the inclusion criteria. Of the 280 TKAs, 261 (93.21%) were performed for degenerative arthritis. There was no statistically significant difference among cohorts in indication ($\chi^2 = 1.841$, $P = .398$) or sex ($\chi^2 = 1.176$, $P = .555$).

Table 1 lists the cohorts' baseline demograph-

Table 1. **Analysis of Variance of Baseline Demographics by Hemostasis Type**

	Age, y		Body Mass Index		Preoperative Hemoglobin Level, g/dL	
Hemostasis Type	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**
Traditional electrocautery	61.5	9.9	35.6	6.5	13.5	1.6
Bipolar sealer	65.0	10.7	35.8	9.7	12.8	1.4
Argon beam coagulation	63.9	9.7	40.9	11.3	13.0	1.6
F	1.92		4.49		3.92	
P	.15		.01		.02	

ics (mean age, BMI, preoperative Hb level) and comparative ANOVA results. TOSTs of equivalence were performed to compare operative time, EBL, 48-hour wound drainage, and postoperative Hb-level depreciation among hemostasis types. Changes in Hb level were calculated for the immediate postoperative period and time of discharge (**Table 2**). ANOVA of hospital length of stay demonstrated no significant difference in means among groups ($P = .09$).

The cohorts were compared with respect to use of postoperative transfusions and incidence of postoperative AEs (**Table 3**). The TE cohort did not have any AEs. Of the 203 BS patients, 14 (7%) had 1 or more AEs, which included acute kidney injury (3 cases), electrolyte disturbance (3), urinary tract infection (2), oxygen desaturation (2), altered mental status (1), pneumonia (1), arrhythmia (1), congestive heart failure exacerbation (1), dehiscence (1), pulmonary embolism (2), and hypotension (1). Of the 36 ABC patients, 1 (3%) had arrhythmia, pneumonia, sepsis, and altered mental status.

Discussion

With the population aging, the demand for TKA is greater than ever.[1] As surgical volume increases, the ability to minimize the rates of intraoperative bleeding, postoperative anemia, and transfusion is becoming increasingly important to patients and the healthcare system. There is no consensus as to which cautery method is ideal. Other investigators have identified differences in clinical outcomes between cautery systems, but reported results are largely conflicting.[10,12-20] In addition, no one has

Table 2. **Two One-Sided Tests of Equivalence for Postoperative Outcomes by Hemostasis Type**

Hemostasis Type	Operative Time, min		Estimated Blood Loss, mL		48-Hour Drainage, mL		Change in Hemoglobin Level, g/dL			
							<24 h		On Discharge	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Traditional electrocautery	101	16.7	131	275	375	333	1.8	0.98	3.2	1.6
Bipolar sealer	98.7	26.0	55.8	61.6	608	392	1.7	0.96	3.2	1.0
Argon beam coagulation	88.8	17.2	83.3	169	576	296	2.1	0.82	3.0	1.0
Threshold	10		150		150		1		1	
$P_{ABC–BS}$	.499		<.001		.041		<.001		<.001	
$P_{TE–BS}$	.077		<.001		.904		<.001		<.001	
$P_{ABC–TE}$	.652		<.001		.726		.001		.001	

Table 3. **χ^2 Analysis of Postoperative Outcomes by Hemostasis Type**

Hemostasis Type	Postoperative Transfusion	Adverse Event Before Discharge
Traditional electrocautery	5/41	0/41
Bipolar sealer	39/203	14/203
Argon beam coagulation	3/36	1/36
χ^2	3.679	5.957
P	.159	.051

studied the utility of ABC in TKA. In the present retrospective cohort analysis, we hypothesized that TE, BS, and ABC would be clinically equivalent in primary TKA with respect to EBL, 48-hour wound drainage, operative time, and change from preoperative Hb level.

The data on hemostatic technology in primary TKA are inconclusive. In an age- and sex-matched study comparing TE and BS in primary TKA, BS used with shed blood autotransfusion reduced homologous blood transfusions by a factor of 5.[16] In addition, BS patients lost significantly less total visible blood (intraoperative EBL, postoperative drain output), and their magnitude of postoperative Hb-level depreciations at time of discharge was significantly lower. In a multicenter, prospective randomized trial comparing TE with BS, adjusted blood loss and need for autologous blood transfusions were lower in BS patients,[10] though there was no significant difference in Knee Society Scale scores between the 2 treatment arms. However, analysis was potentially biased in that multiple authors had financial ties to Salient Surgical Technologies, the manufacturer of the BS device used in the study. Other prospective randomized trials of patients who had primary TKA with either TE or BS did not find any significant difference in postoperative Hb level, postoperative drainage, or transfusion requirements.[19]

ABC has been studied in the context of orthopedics but not joint arthroplasty specifically. This technology was anecdotally identified as a means of attaining hemostasis in foot and ankle surgery after failure of TE and other conventional means.[22] ABC has also been identified as a successful adjuvant to curettage in the treatment of aneurysmal bone cysts.[21] However, ABC has not been compared with TE or BS in the orthopedic literature.

In the present study, analysis of preoperative variables revealed a statistically but not clinically significant difference in BMI among cohorts. Mean (SD) BMI was 35.6 (6.5) for TE patients, 35.8 (9.7) for BS patients, and 40.9 (11.3) for ABC patients. (Previously, BMI did not correlate with intraoperative blood loss in TKA.[25]) Analysis also revealed a statistically significant but clinically insignificant and inconsequential difference in Hb level among cohorts. Mean (SD) preoperative Hb level was 13.5 (1.6) g/dL for TE patients, 12.8 (1.4) g/dL for BS patients, and 13.0 (1.6) g/dL for ABC patients. As decreases from preoperative baseline Hb levels were the intended focus of analysis—not absolute Hb levels—this finding does not refute postoperative analyses.

Our results suggest that, though TE may have relatively longer operative times in primary TKA, it is clinically equivalent to BS and ABC with respect to EBL and postoperative change in Hb levels. In addition, postoperative drainage was lower in TE than in BS and ABC, which were equivalent. No significant differences were found among hemostasis types with respect to postoperative transfusion requirements.

The prevalence distribution of predischarge AEs trended toward significance ($\chi^2 = 5.957$, $P = .051$), despite not meeting the predetermined α level. Rates of predischarge AEs were 0% (0/41) for TE patients, 7% (14/203) for BS patients, and 3% (1/36) for ABC patients. AEs included acute kidney injuries, electrolyte disturbances, urinary tract infections, oxygen desaturation, altered mental status, sepsis/infections, arrhythmias, congestive heart failure exacerbation, dehiscence, pulmonary embolism, and hypotension. Clearly, many of these AEs are not attributable to the hemostasis system used.

Limitations of this study include its retrospective design, documentation inadequate to account for drainage amount reinfused, and limited data on which clinical insignificance thresholds were based. In addition, reliance on historical data may have introduced bias into the analysis. The historical data used to increase the size of the TE cohort may reflect a period of relative inexperience and may have contributed to the longer operative times relative to those of the ABC cohort (Dr. Levine used ABC later in his career).

Traditional electrocautery remains a viable option in primary TKA. With its low cost and hemostasis equivalent to that of BS and ABC, TE deserves consideration equal to that given to these more modern hemostasis technologies. Cost per case is about $10 for TE versus $500 for BS and $110 for ABC.[17] Soaring healthcare expenditures may warrant returning to TE or combining cautery techniques and other agents in primary TKA in order to reduce the number of transfusions and associated surgical costs.

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