



## Transfusion Cost Savings with Tranexamic Acid in Primary Total Knee Arthroplasty from 2009 to 2012



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### ABSTRACT

Tranexamic acid (TXA) has proven to be very advantageous to the total knee arthroplasty (TKA) population. With TXA, the need for allogeneic blood transfusion is reduced and thus hospital costs are reduced. In our hospital system, before TXA was used, facility cost was an estimated \$84.90/TKA for blood transfusion and required 0.13 man-hours/TKA (transfusion rate 6.5%); after incorporating intravenous TXA, cost was \$82.59/TKA for blood transfusion and TXA medication and 0.007 man-hours/TKA (transfusion rate 0.3%). There were no transfusions when TXA was applied topically, and the facility cost was \$39.14/TKA and no employee hours consumed. Topical TXA has the potential to significantly reduce blood transfusions and decrease hospital man-hours/TKA as well as achieve larger cost saving.

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Tranexamic acid (TXA) is a plasminogen-activator that has been used widely in many surgical specialties to help reduce the need for allogeneic blood transfusions. TXA therapy has been applied to total joint arthroplasty with similar reduction in transfusion rates [1–12]. There are also several risks secondary to blood transfusion that are reduced or removed when TXA is employed: transfusion reactions, infections, fluid overload and altered mental status; all of which may lead to prolonged hospitalization [1,4,10,13]. The financial impact of TXA could be very important to TKA due to changes in health-care economics.

There are a number of publications that address costs associated with topical-TXA versus no-TXA in TKA populations [1,3,4,7,9,14]. The drug cost of topical-TXA varied from as little as \$6 in some countries to \$80 at some U.S. locations [3,7,15]. Other authors looked at pharmacy cost, blood bank cost, and total direct cost of topical-TXA in primary TKA [1,4,7,14]. Pharmacy cost was higher in topical-TXA TKA patients than in no-TXA TKA patients [1]. Blood bank cost was lower in topical-TXA TKA than in no-TXA TKA [1,7]. Total direct cost was lower in topical-TXA than in no-TXA TKA [1,4,7,14].

We have chosen to ask two questions of a clearly defined, comparative dataset: (1) Does TXA in TKA result in reduced facility costs (the cost of TXA and the cost of allogeneic blood transfusion expressed in dollars per TKA) and (2) Does TXA in TKA result in reduced man-hour costs (the time needed to successfully deliver a unit of blood and to address possible transfusion reactions and/or any other untoward effects.).

### Materials and Methods

This is a case-control study of a population originally compiled by Wind et al for a study of transfusion rates comparing TXA usage in total knee arthroplasties (TKAs) [11]. From 2009 to 2012, four surgeons at a single institution performed all of the TKA in this study. One surgeon adopted the protocol initially; 6 months later two additional surgeons adopted the protocol; and 6 months after that (12 months since inception) a fourth surgeon adopted the protocol; all four surgeons involved in this analysis were fellowship trained in adult reconstruction at this tertiary care center. Pre-operatively, there was no additional intervention, such as Procrit or iron supplementation, for patients at a high risk of blood transfusion. Post-operatively, all patient drains were clamped for 30 minutes. Patient records were reviewed and TKA patients were categorized to one of three groups (no-TXA, IV-TXA, and topical-TXA).

Wind et al identified patients through chart review of TKA performed between 2009 and 2012 [11]. Patients were not randomized; allocation was dependent on date of TKA (earlier TKA were performed without TXA) and on cardiovascular and thromboembolic health status (IV-TXA and topical-TXA). Patients who did not receive TXA were designated as “controls” (no-TXA,  $n = 1839$ ). Patients who received TXA during the course of surgery were defined as “cases” and were subdivided into IV-TXA ( $n = 330$ ) or topical-TXA ( $n = 130$ ). There were no significant differences in demographics or pre-operative matocrit between groups (Tables 1 and 2) [11].

IV-TXA was administered as 1-gram infusion within 1 hour of incision with an additional gram administered as wound closure began [11]. The topical-TXA group is made of patients who had a heart attack within the previous 6 months, who had a stent placement within the previous 12 months, or who had a previous embolic event [11].

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**Table 1**  
Demographic Information for Male Patients ( $n = 952$ ) (reprinted from Wind et al [11]).

	Age	Height	Weight (lb)	BMI
No-TXA, mean (range)	66 (31–94)	5'9" (5'1"–6'7")	226 (129–460)	32.1 (19.3–61.8)
IV-TXA, mean (range)	65 (40–89)	5'9" (5'3"–6'6")	221 (150–355)	31.2 (23.1–48.3)
Topical-TXA, mean (range)	69 (52–85)	5'9" (5'4"–6'5")	217 (140–277)	30.4 (22–40.8)

For these patients, TXA was placed in the wound before closure and the hemovac drain was clamped for 30 minutes post operatively [11].

Allogeneic blood transfusion is the event for determining possible cost savings of TXA usage, therefore a standard measure is needed to determine when to administer a transfusion; a hemoglobin below 8 g/dL was set as the transfusion trigger for all patients and no variations were noted [11].

Several elements contribute to facility cost: cost of packed red blood cells per unit, cost associated with tranexamic acid per dose, cost of pre-hospitalization lab work as well as lab work required when a transfusion is ordered, and finally equipment utilization costs. Assistance from the hospital billing and purchasing departments allowed us to assign specific values to each element.

The man-hour cost was determined by working directly with hospital administration, nursing services and laboratory services. The pathway for a unit of packed red blood cells (PRBCs), from donor to TKA patient recipient, was evaluated. Provider, nursing, and blood bank protocols were reviewed to identify the minimum man-hour components of each element on the transfusion pathway. The elements were analyzed for three different outcomes: (1) the time needed to transfuse one unit of PRBCs, (2) the time required to transfuse additional units of PRBCs, and (3) the time associated with management of a transfusion reaction (Table 3).

Statistical analyses of costs were not performed. Our goal was not to determine if there was a statistically significant reduction but to determine if there was a cost reduction that would have practical significance

## Results

The cost of packed red blood cells (PRBC) was \$1130/U, each additional unit of PRBC was \$291/U, and the cost of a transfusion reaction during the first unit of transfused blood cost \$1197/reaction. The cost associated with TXA per dose at our institution was \$39.14, one dose being used intra-operatively for topical application. For the two-dose regimen that was needed for intravenous application during this study, the cost was \$78.28.

In the no-TXA group, there were 120 blood transfusions (6.5% of 1839 TKA) at a facility cost of \$84.90/TKA (\$156,137 total). This is compared to 1 transfusions in the IV-TXA group (0.3% of 330 TKA) with a facility cost of \$82.59/TKA (\$27,254 total) and is compared to 0 transfusions in the topical-TXA group (0% of 130 THA) with a facility cost of \$39.14/TKA (\$5,088 total) (Table 4). Thus, the IV-TXA group

**Table 2**  
Demographic Information for Female Patients ( $n = 952$ ) (reprinted from Wind et al [11]).

	Age	Height	Weight (lb)	BMI
No-TXA, mean (range)	65 (31–91)	5'4" (4'6"–6'2")	202 (101–455)	34.4 (19.4–68)
IV-TXA, mean (range)	67 (42–91)	5'3" (4'9"–5'9")	188 (113–335)	31.9 (18.9–47.6)
Topical-TXA, mean (range)	72 (52–91)	5'4" (4'7"–5'9")	192 (133–274)	31.7 (22–46.4)

experienced a 95.38% reduction in blood transfusions while the topical-TXA group experienced a 100% reduction in blood transfusions when compared to the no-TXA group.

Analysis of the ratio of money spent on blood transfusion when TXA is used versus when it is not used revealed that when topical-TXA is utilized, there is a 53.90% reduction in cost to the institution associated with blood transfusion and drug delivery, and when IV-TXA is used, the savings is 2.72% when compared to blood transfusion in patients that do not receive TXA (Table 4).

Analysis of man-hour time utilized reveals that it takes at least 95 minutes (1.58 man-hours) to transfuse the first unit of PRBC. When additional units are ordered, another 40 minutes per unit is added to the initial 95 minutes. So a patient receiving 2 U of PRBC will require 135 minutes (2.25 man-hours), while a person receiving 4 U would require 215 minutes (3.58 man-hours). If a patient had a blood transfusion reaction, the additional nursing, administrative and blood bank procedures would require 205 minutes (3.42 man-hours), this was assuming that the transfusion reaction was noted during the first unit of transfused blood (Table 3).

In the no-TXA group, transfusions cost 0.13 man-hours/TKA (236.6 man-hours total) while the man-hours cost for IV-TXA was 0.007 man-hours/TKA (2.25 man-hours total) and the man-hours cost for topical-TXA group was zero man-hours/TKA (zero man-hours total).

The ratio of man-hours spent on blood transfusions when TXA is used versus when it is not used revealed that when topical-TXA is utilized, there is a 100% reduction in man-hours associated with blood transfusion, and when IV-TXA is used, there is an 94.62% reduction in man-hours when compared to patients who did not receive TXA (Table 4).

## Discussion

Tranexamic acid treatment in total joint arthroplasty continues to evolve and demonstrates benefits to the patients undergoing these procedures and to the institutions using TXA. To our knowledge, this is the first paper to examine both the facility and the man-hour cost savings associated with TXA usage in TKA at a major joint replacement center. We found that TXA usage was associated with a reduction in facility costs (range: 53.90% topical-TXA to 2.72% IV-TXA) and a reduction in man-hour costs (range: 100% topical-TXA to 94.62% IV-TXA).

There are several weaknesses in our study. First, this is a retrospective study using data from the previous analysis of Wind et al that showed the effectiveness of TXA in reducing transfusions in our total knee population [11]. A prospective analysis would be a better method to track patient cost in real-time and would require a tracking system or program in place. Second, the review takes place at a single institution, and thus it may be difficult to extrapolate results across different systems and networks. Third, by allocating patients to the topical-TXA group based on medical risk factors, there is the potential for selection bias. Fourth, the lack of blood transfusions and the size of the population in the topical-TXA group clearly create a bias in our cost-analysis; thus, the cost-impact of topical-TXA should continue to be investigated. Fifth, we are unable to create a direct comparison of IV-TXA and topical-TXA due to the discrepancy in population sizes and incidence of blood transfusions. Sixth, outcomes, including complications and adverse events, were not reviewed as part of this analysis, and could affect price estimates significantly. Seventh, the man-hour cost analysis was based on what is perceived as minimum times it takes to accomplish tasks during blood transfusion. These times relating to health care workers represent the most accurate pathway we could identify to perform this review. Electronic Medical Records (EMR) may allow this pathway to be more accurately tracked in a prospective manner and give more precise results in the future.

Several authors have attempted to quantify indirect costs either in the general or orthopedic literature as it relates to blood transfusion. Ralley et al determined that before TXA, their per patient transfusion cost was \$105.98 for TKA and THA patients, while after it was

**Table 3**  
Transfusion time requirements.

Providers (Physicians, PA, NP)	Time [min]	Floor Staff (RN, PCA)	Time [min]	Miscellaneous Staff (Lab, Transport)	Time [min]	Total Time
Consent for blood	10	Acknowledge orders	5			
Input orders	5	Equipment acquisition	10	Blood bank receives orders/call	10	
		Nurse receives blood	25	Processes request		
		Nurse/patient education		Transport unit of blood to floor		
		Pre-transfusion VS check				
		verification (6 points)				
		Begin transfusion within 20 minutes				
		VS 15 min post initiation	30			
		AND/OR Sign of any reaction				
		Transfusion 2–4 hours				
		VS 15 minutes post completion				
Per additional unit		Equipment return	30	Per additional unit	10	Without transfusion reaction for first unit = 95 minutes
		Equipment/unit switch		Blood bank		Subsequent units after first unit completed = 40 minutes per subsequent unit
		VS monitor AND/OR Sign of any reaction				
Transfusion reaction	30	Transfusion reaction stopped	30	Transfusion reaction	45	With transfusion reaction (diagnosed during first unit) = 205 minutes
Pathologist review		Event report completed		Blood bank processing	5	
		Unit sent back to blood bank		Blood bank disposal		
		Notify provider				
Totals	45		130		70	

implemented, it reduced to \$40.98, which they estimated saved approximately \$65,000 Canadian dollars annually in their system [15]. Shander et al described a very thorough review of blood transfusion and the total cost associated with this in the general population, by utilizing a computer program that was tasked specifically for calculating system specific costs once the variables were input, unfortunately, it was not financially feasible to use this program in our study [16]. As another comparison, it costs \$39.14 US per dose at our facility for topical or intravenous application. In another cost-analysis of both total hip and total knee patients, Gillette et al discussed intangible, direct, and indirect cost analysis as it pertains to elements such as blood/lab cost, pharmacy and surgical suite associated cost, which was similar to our analysis [17]. Our study differed, though, in that our cost analysis attempted to look at both the facility cost and man-hour cost associated with blood transfusion that was not listed on the hospital bill, but rather by the time and effort quantified by average salary of the employees at the different levels of the transfusion pathway. It was our belief that while some of this cost is likely captured in the room charges and hospital bill of the total knee arthroplasty patients, there are components of staff time

that go underappreciated and that are an important part of the savings observed from this study.

Even though this review is about cost analysis, several findings may contribute to patient care. The amount of time that is dedicated to performing a blood transfusion for even 1 U of PRBCs was revealing when it is broken into its components. The highest impact is to the inpatient hospital unit and nursing staff. While Shander et al showed the cost associated with delivering and monitoring blood products to patients, their paper did not describe a time breakdown of this in the manner in which we have done [16]. Regardless of institution size, from a high volume joint arthroplasty center to a small community hospital, to reduce the amount of cumulative time that staff spends performing blood transfusions, and re-direct that time into other processes improves efficiency, safety, and patient care. Our analysis revealed that over 220 hours of employee productivity can be gained when the same number of TKAs accomplished with TXA were compared to the number performed without.

Transfusion reactions also have associated facility cost and man-hour cost consumed in treatment. In reviewing the cost of transfusion reactions, we did note that there were no transfusion reactions to account for in our current TKA study population. For comparison purposes, our previous analysis reviewing the THA population noted 2 transfusion reactions (2/1595) and cost \$2,979 and 6.8 manpower hours. The national average for a transfusion reaction is 1–3%, depending on what reaction occurs. This is another risk to the patient that can be mitigated if the quantity of transfused blood can continue to see significant reductions.

The data from this study can be used to identify potential areas of savings in both a hospital system and also to the patient when TXA is used appropriately to reduce blood transfusions. Our review identified a potential savings of 95% or greater on blood transfusion cost compared to the previous baseline in the TKA population, when IV or topical TXA is used. The combination of savings from the facility and man-hour costs of blood transfusion can be over \$600,000 in a 10-year period if appropriate surgical case volume is continued. In addition, several studies have shown decreases in hospital stay when TXA is utilized. Gilbody et al showed a decrease in hospital stay by 1.2 days when topical TXA is used in its TKA population, and also 1.0 days in its THA population [4]. Alshryda et al also showed decreased length of hospital stay by 1.2 days in their TKA analysis [14]. Chimento et al additionally showed a decrease length of stay, from 5.3 to 4.7 days in TKA patients [1].

This financial savings is not only to the hospital system, but also for the patients, and is extremely important due to healthcare changes.

**Table 4**  
Costs Associated with Blood Transfusions and Use of TXA in Primary Total Knee Arthroplasty.

	No TXA	TXA IV	TXA Topical
TKA, n	1839	330	130
Transfusions, n	120	1	0
Transfusions cost, \$	\$156,137	\$1422	\$0
TXA cost, \$	\$0	\$25,832	\$5088
TXA and transfusions cost, \$ =	\$156,137	\$27,254	\$5088
Transfusions labor, hours =	236.6	2.25	0
Transfusion rate, % =	120/1839 (6.5%)	1/330 (0.3%)	0/130 (0%)
TXA cost per TKA performed, \$	\$0	\$78.28	\$39.14
TXA and transfusions cost per TKA performed, \$	\$84.90	\$82.59	\$39.14
Transfusions labor per TKA performed, hrs	0.13	0.007	0
Reduction in transfusion rate per TKA performed		95.38%	100%
Reduction in TXA and transfusions cost per TKA performed		2.72%	53.90%
Reduction in transfusions labor per TKA performed		94.62%	100%

$$\text{Reduction per TKA performed} = \frac{\text{measure}_{\text{No TXA}} - \text{TXA measure}_{\text{TXA}}}{\text{measure}_{\text{No TXA}}}$$

Our facility has modified its total joint pre-operative blood typing and screening processes secondary to the improvement in transfusion rates accomplished by our blood conservation management program, for which TXA is a huge component. Patients who are enrolled for TKA at our facility no longer have this labwork added to their pre-operative evaluation requirement. Financial savings may also be impacted by insurance coverage. According to Medicare guidelines, if a patient has not completely paid a deductible at the time of surgery and requires a blood transfusion, the patient may be charged for up to 3 U of blood [18]. In addition, in the event of a transfusion related error, the hospital may not get payment for these services [19].

## Conclusion

In conclusion, the literature supports the use of TXA in total knee arthroplasty and revision procedures to help reduce allogeneic blood transfusion, and the risks associated with that practice. Some authors have additionally shown that topical-TXA is equivalent to IV-TXA [11,12] and we have shown a sizeable cost savings for topical-TXA over IV-TXA. The drug costs are less, the transfusion rates are lower, and the man-hours needed due to transfusions are lower; thus, it may be that topical-TXA is the best blood conservation tactic for all TKA without contraindications.

In addition to the benefits to the patient, the cost savings to the facility can be equally profound. The facility and man-hour cost savings that have been demonstrated with TXA are tremendous, and the projections in a high volume joint arthroplasty center should be carefully considered in this era of fiscal responsibility.

## References

- Chimento GF, Huff T, Ochsner JL, et al. An evaluation of the use of topical tranexamic acid in total knee arthroplasty. *J Arthroplasty* 2013;28(8 Suppl):74.
- Dahuja A, Dahuja G, Jaswal V, et al. A prospective study on role of tranexamic acid in reducing postoperative blood loss in total knee arthroplasty and its effect on coagulation profile. *J Arthroplasty* 2014;29:733.
- Georgiadis AG, Muh SJ, Silverton CD, et al. A prospective double-blind placebo controlled trial of topical tranexamic acid in total knee arthroplasty. *J Arthroplasty* 2013;28(8 Suppl):78.
- Gilbody J, Dhotar HS, Perruccio AV, et al. Topical tranexamic acid reduces transfusion rates in total hip and knee arthroplasty. *J Arthroplasty* 2014;29:681.
- Karam JA, Bloomfield MR, Diiorio TM, et al. Evaluation of the efficacy and safety of tranexamic acid for reducing blood loss in bilateral total knee arthroplasty. *J Arthroplasty* 2014;29(3):501.
- Konig G, Hamlin BR, Waters JH. Topical tranexamic acid reduces blood loss and transfusion rates in total hip and total knee arthroplasty. *J Arthroplasty* 2013;28(9):1473.
- Martin JG, Cassatt KB, Kincaid-Cinnamon KA, et al. Topical administration of tranexamic acid in primary total hip and total knee arthroplasty. *J Arthroplasty* 2014;29:889.
- Sarzaeem MM, Razi M, Kazemian G, et al. Comparing efficacy of three methods of tranexamic acid administration in reducing hemoglobin drop following total knee arthroplasty. *J Arthroplasty* 2014;29:1521.
- Smit KM, Naudie DD, Ralley FE, et al. One dose of tranexamic acid is safe and effective in revision knee arthroplasty. *J Arthroplasty* 2013;28(8 Suppl.):112.
- Tuttle JR, Ritterman SA, Cassidy DB, et al. Cost benefit analysis of topical tranexamic acid in primary total hip and knee arthroplasty. *J Arthroplasty* 2014;29:1512.
- Wind TC, Barfield WR, Moskal JT. The effect of tranexamic acid on blood loss and transfusion rate in primary total knee arthroplasty. *J Arthroplasty* 2013;28(7):1080.
- Patel JN, Spanyer J, Smith LS, et al. Comparison of intravenous versus topical tranexamic acid in total knee arthroplasty: A prospective randomized study. *J Arthroplasty* 2014;29:1528.
- Browne JA, Adib F, Brown TE, et al. Transfusion rates are increasing following total hip arthroplasty: risk factors and outcomes. *J Arthroplasty* 2013;28(8 Suppl):34.
- Alshryda S, Mason J, Vaghela M, et al. Topical (intra-articular) tranexamic acid reduces blood loss and transfusion rates following total knee replacement: a randomized controlled trial (TRANX-K). *J Bone Joint Surg Am* 2013;95(21):1961.
- Ralley FE, Berta D, Binns V, et al. One intraoperative dose of tranexamic acid for patients having primary hip or knee arthroplasty. *Clin Orthop Relat Res* 2010;468(7):1905.
- Shander A, Hofmann A, Ozawa S, et al. Activity- based costs of blood transfusions in surgical patients at four hospitals. *Transfusion* 2010;50(4):753.
- Gillette BP, Maradit Kremers H, Duncan CM, et al. Economic impact of tranexamic acid in healthy patients undergoing primary total hip and knee arthroplasty. *J Arthroplasty* 2013;28(8 Suppl):137.
- Medicare general information, eligibility, and entitlement. Chapter 3—deductibles, coinsurance amounts, and payment limitations (Rev. 82, 11-15-13); 2013 [<http://www.cms.gov/Regulations-and-Guidance/Guidance/Manuals/downloads/ge101c03.pdf>].
- Gluck F. Hospitals look to limit transfusions. *USA Today* 2013;8.