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Does Tranexamic Acid Reduce Blood Transfusion Cost for Primary Total Hip Arthroplasty? A Case–Control Study

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ABSTRACT

Peri-operative tranexamic acid (TXA) significantly reduces the need for allogeneic blood transfusion in total hip arthroplasty (THA) and thus hospital costs are reduced. Before employing TXA in primary THA at our institution, facility costs were $286.90/THA for blood transfusion and required 0.45 man-hours/THA (transfusion rate 19.87%). After incorporating TXA, the cost for intravenous application was $123.38/THA for blood transfusion and TXA medication and 0.07 man-hours/THA (transfusion rate 4.39%) and the cost for topical application was $132.41/THA for blood transfusion and TXA and 0.14 man-hours/THA (transfusion rate 12.86%). TXA has the potential to reduce the facility cost per THA and the man-hours/THA from blood transfusions.

Tranexamic Acid (TXA) is a plasminogen-activator inhibitor that has been used widely in many surgical specialties to help reduce the need for allogeneic transfusion. TXA therapy has more recently been applied to total joint arthroplasty with similar reduction in allogeneic transfusion rates. The impact on patient care and outcomes of TXA application in the peri-operative period is primarily a reduction in the need for allogeneic transfusion in patients immediately after total hip arthroplasty [1–4]. Additionally, several risks secondary to blood transfusion are reduced or removed: transfusion reactions, infections, fluid overload and altered mental status; all of which may lead to prolonged hospitalization [5,6]. Health-care delivery is undergoing changes in focus; the economics of managed care, cost-bundling, and health-care reform mean that the financial impact of TXA could be very important to THA.

Although there have been many publications on the effectiveness of TXA on THA patient care as it relates to transfusion rates [1–4,7], there are few references to the economic savings that can be achieved by a health care system when this medication is properly applied peri-operatively [6,8].

The facility cost associated with TXA is not difficult to assess; we have defined it as the cost of TXA and the cost of allogeneic transfusion expressed in dollars per THA. The man-hour cost of allogeneic transfusion has been defined as the time needed to successfully deliver a unit of blood and to address possible transfusion reactions.

Our analysis will review the cost-savings achieved by one institution over a four-year period when TXA was used in a primary THA population. Cost-savings will be expressed as facility cost and man-hour cost. Thus we will determine how TXA can impact hospital resource utilization.

To this end we asked three questions: (1) Does TXA in THA result in reduced facility costs?, (2) Does TXA in THA result in reduced man-hour costs? and (3) Is there a difference in facility costs and man-hour costs depending on the delivery mechanism of TXA (IV versus Topical) in THA?

Materials and Methods

We use the transfusion data and the patient cohort from a case–control study originally compiled by Wind et al. at our institution, to perform the cost analysis comparing TXA usage [4]. THA patients were categorized to one of the three treatment groups (no-TXA, IV-TXA, and Topical-TXA) during record reviews. From January 2009 to March 2013, four surgeons at a single institution performed all THAs in this study. One surgeon adopted the protocol initially; six months later two additional surgeons adopted the protocol; and six 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.

Wind et al. identified patients through chart review of THAs performed between January 2009 and March 2013 [4]; IRB Approval was obtained before gathering patient data. Patients who did not receive TXA were designated as "controls" (n = 1047). Patients who received TXA during the course of surgery were defined as "cases" and

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were subdivided into IV-TXA (n = 478) or Topical-TXA (n = 70). It was these data from Wind et al. that we utilized for our measure of direct and indirect costs [4].

Patients were not randomized; allocation was dependent on date of THA (earlier THAs were performed without TXA) and on cardiovascular and thromboembolic health status (IV-TXA and Topical-TXA); all patients with complete records were included in this retrospective review. Wind et al. examined demographics for the study groups and found one significant difference ($P = 0.001$), males were approximately 5.45 years younger than females (60.55 ± 12.64 years versus 66.00 ± 11.35 years); there were no significant differences between treatment groups [Tables 1 and 2 reprinted with permission]. Wind et al. also reported rates of thromboembolic events and found no statistically significant differences between groups [4].

All patients, regardless of TXA group, received single shot spinal anesthetic unless contraindicated by history of spine surgery, spinal deformity, or anesthesiologist preference. At our facility at least 90% of our patients receive single shot spinal anesthetic. All patients received Coumadin as prophylaxis against deep vein thrombosis; and all patients received hemovac drains post operatively [4]. Patients who received THA surgery before the TXA protocol was implemented make up the control group (No-TXA). TXA protocol is divided into two groups: IV-TXA and Topical-TXA.

IV-TXA was administered as a one-gram infusion within one hour of incision with an additional gram administered as wound closure began [4]. The Topical-TXA group is made of patients who had a heart attack within the previous six months, who had a stent placement within the previous 12 months, or who had a previous embolic event [4]. For these patients, TXA was placed in the wound before closure and the hemovac drain was clamped for 30 min post operatively [4].

Autologous 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 regardless of TXA dosage (No-TXA, IV-TXA, or Topical-TXA) [4].

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 (PBRCs), from donor to THA 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. To measure transfusion reaction cost, only the standard steps of treating any transfusion reaction were measured, i.e. nursing protocol of stopping blood transfusion and sending to un-transfused blood to blood bank, blood bank employees processing that un-transfused blood, pathologist review of un-transfused blood, and the charting and administrative steps of all three levels, once again to evaluate the minimum man-hour component. Average institutional salary information was then used to determine the cost associated with manpower utilization.

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.

Table 1
Demographic Information for Male Patients (n = 684) [Reprinted From Wind et al. [4].

	Average Age	Average Height	Average Weight	Average BMI
No-TXA (n = 464)	60	5'10"	210 lb	30
Range	25–93	5'6"–6'0"	99–396	15.1–55.3
IV-TXA (n = 80)	61	5'10"	209 lb	29.3
Range	38–85	5'5"–6'5"	125–298	19.1–41
Topical-TXA (n = 22)	65	5'10"	210 lb	30
Range	38–87	5'4"–6'4"	133–335	20.3–43.1

Table 2
Demographic Information for Female Patients (n = 911) [Reprinted From Wind et al. [4].

	Average Age	Average Height	Average Weight	Average BMI
No-TXA (n = 594)	66	5'4"	174 lb	30
Range	19–90	4'3"–6'4"	91–389	17.2–54.4
IV-TXA (n = 111)	64	5'4"	172 lb	29
Range	33–86	4'4"–6'0"	101–389	18.7–49.1
Topical-TXA (n = 25)	70	5'3"	165 lb	29
Range	53–88	4'10"–5'8"	106–239	19.3–42.3

Results

Facility cost is calculated as the cost of allogeneic blood transfusion plus the cost of TXA, for the control group (No-TXA) facility cost is only the cost of allogeneic blood transfusion (Table 3). Examination of hospital billing practices at our institution allowed us to determine that the cost of packed red blood cells (PRBCs) was $1130/unit, each additional unit of PRBC was $291/unit, and the cost of a transfusion reaction during the first unit of transfused blood was $1197/reaction. The cost associated with TXA per dose 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 208 blood transfusions (19.87% of 1047 THAs) at a facility cost of $300,380 ($286.90/THA). This is compared to 21 transfusions in the IV-TXA group (4.39% of 478 THAs) with a facility cost of $58,977.95 ($123.38/THA) and is compared to 9 transfusions in the Topical-TXA group (12.86% of 70 THAs) with a facility cost of $9269.84 ($132.41/THA). 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 54% reduction in cost associated with blood transfusion, and when IV TXA is used, the savings is 57% when compared blood transfusion in patients that do not receive TXA (Table 3).

The man-hours required for allogeneic blood transfusion and possible transfusion reactions are a second area of possible cost savings with the use of TXA (Table 4). The man-hour required to transfuse the first unit of PRBC is at least 95 min. When additional units are ordered, an additional 40 min per unit is added to the initial 95 min. So a patient receiving 2 units of PRBC will require 135 min (95 + 40), while a person receiving 4 units would require 215 min (95 + (3 × 40)). If a patient had a blood transfusion reaction, the additional nursing, administrative and blood bank procedures would require 205 min; 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 472.2 man-hours (0.45 h/TH) while the man-hours cost for IV-TXA was 32.2 man-hours (0.07 h/THA) and the man-hours cost for Topical-TXA group was 9.9 man-hours (0.14 h/THA). 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 68.89% reduction in man-hours associated with blood transfusion, and when IV TXA is used, there is an 84.44% reduction in man-hours when compared to patients who did not receive TXA (Table 3).

Table 3
Total Costs Associated With Blood Transfusions and Use of TXA in Primary Total Hip Arthroplasty.

	No TXA	TXA IV	TXA Topical
THA, n	1047	478	70
Transfusions, n	208	21	9
Transfusions Cost, $	$300,380.54	$21,560.11	$6530.04
TXA Cost, $	$0	$37,417.84	$2739.80
TXA and Transfusions Cost, $ =	$300,380.54	$58,977.95	$9269.84
Transfusions Labor, h =	472.2	32.3	9.9
Transfusion Rate, % =	208/1047 (19.87%)	21/478 (4.39%)	9/70 (12.86%)
TXA Cost per THA performed, $	$0	$78.28	$39.14
TXA and Transfusions Cost per THA performed, $	$286.90	$123.38	$132.41
Transfusions Labor per THA performed, h	0.45	0.07	0.14
Reduction in Transfusion Rate per THA performed		77.91%	35.28%
Reduction in TXA and Transfusions Cost per THA performed		57.00%	53.85%
Reduction in Transfusions Labor per THA performed		84.44%	68.89%

Reduction per THA performed $= \frac{measure_{No\ TXA} - measure_{TXA}}{measure_{No\ TXA}}$

The data indicate little difference in facility costs between IV-TXA and Topical-TXA application in THA ($123.38 IV-TXA versus $132.41 Topical-TXA). Yet, blood transfusions took twice as many man-hours in the Topical-TXA group compared to the IV-TXA group (0.07 IV-TXA versus 0.14 Topical-TXA).

Discussion

Tranexamic acid treatment in total joint arthroplasty continues to demonstrate 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 man-hour cost savings associated with TXA usage in THA at a major joint arthroplasty center. We found that TXA usage was associated with a reduction in facility costs (range: 54% Topical-TXA to 57% IV-TXA) and a reduction in man-hour costs (range: 69% Topical-TXA to 84% IV-TXA).

There are several weaknesses in our study. First, this is a retrospective study using the exact same data from the previous analysis by Wind et al. that showed the effectiveness of TXA in our total hip population. 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, outcomes, including complications and adverse events, were not reviewed as part of this analysis, and could affect price estimates significantly. Specifically, with tranexamic acid the major complication would be a thromboembolic event, but rarer complications include concerns for peri-prosthetic joint infections, long-term effects of tranexamic acid on hardware wear rates, and systemic toxicity concerns. While these ramifications could significantly increase hospital stay, necessitate need for additional surgeries, and increase morbidity, there have been no reports to our knowledge of increased rates of PPI or DVT/PE in patients who are properly screened and given TXA. Additionally, Alshryda and Mason et al. have just released results that show no biomechanical adverse effects on common TJA materials from topical TXA [9]. Fourth, the man-hour cost analysis was based on average salaries and what is perceived as minimum times it takes to accomplish tasks during blood transfusion. These

Table 4
Man-Hours to Perform Various Tasks Associated With Allogeneic Blood Transfusions.

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				
Input orders	5	Call/notify blood bank	5			
				Blood bank receives orders/call Processes request		
		Equipment acquisition	10	Transport unit of blood to floor	10	
		Nurse receives blood				
		Nurse/patient education				
		Pre-transfusion VS check				
		Blood verification (6 points)				
		Begin transfusion within 20 min	25			
		VS 15 min post initiation AND/OR				
		Sign of any reaction				
		Transfusion 2–4 h VS 15 min post completion				
		Equipment return	30			*Without Transfusion Reaction for First Unit = 95 min*
Per Additional Unit		*Per Additional Unit*		*Per Additional Unit*		*Subsequent Units after First Unit Completed = 40 min per subsequent unit*
		Equipment/unit switch VS monitor AND/OR				
		Sign of any reaction	30	Blood bank	10	
Transfusion Reaction		*Transfusion Reaction*		*Transfusion Reaction*		*With Transfusion Reaction (Diagnosed during First Unit) = 205 min*
		Transfusion stopped				
		Event report completed				
		Unit tag completed				
		Unit sent back to blood bank		Blood bank processing	45	
Pathologist Review	30	Notify provider	30	Blood bank disposal	5	
Total Time [min]	45		130		70	

times and costs 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.

We found that TXA usage is associated with reduced facility costs, defined as cost of blood transfusion plus cost of TXA. Other researchers, mostly outside the U.S., have found similar results. Niskanen and Korkala demonstrated cost savings associated with TXA use in cemented THAs as early as 2005, showing an average cost of 58 EUR ($79 US) in the TXA group and 90 EUR ($123 US) in the placebo group [7]. Johansson et al. also in 2005, noted that patients who received TXA would save an average of 47 EUR ($64 US) per patient at that time. They used a single dose of TXA pre-operatively at the time of their analysis [8]; we used two doses delivered intravenously perioperatively. Gillette et al. showed that the difference in direct cost to the patients that underwent TJA with and without TXA was approximately $879 per patient, and that only the pharmacy cost was noted to be higher by $140 [6]. Gilbody et al. showed a savings of CAD $10,820 ($10,170 US) for their patients before and after TXA was utilized in total hip and total knee arthroplasty. They also showed a reduction in hospital stay of approximately 1.2 days, further contributing to total cost savings of TJA procedures [2]. Alshryda et al. showed savings of 305 British Pounds Sterling ($450 US) in their evaluation of TXA, although their evaluation only observed topical administration of TXA, while the results in this review show intra-articular as well as intravenous application and cost savings [1].

We also found that TXA was associated with reduced man-hour costs for transfusions in THA. 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 [10]. In a very well designed and comprehensive review, 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 [6]. Our analysis differed in that our man-hour cost analysis attempted to look at both the time and 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 hip arthroplasty patients, there are components of staff time that go underappreciated and that are an important part of the savings observed from this study.

Although there is not an increase in nursing staff due to blood transfusions, the time that they must devote to managing and administering blood transfusions takes time away from their other duties and tasks. The amount of time that is dedicated to performing a blood transfusion for even one unit of PRBCs was revealing, even when it is broken into its components. The highest impact is to the hospital patient care unit and floor nursing staff. Shander et al. showed the cost associated with delivering and monitoring blood products to patients, but did not describe a time breakdown of this in the manner in which we have done [10]. Regardless of hospital size or volume, reducing the amount of cumulative time that staff spends performing blood transfusions, and re-directing that time into other processes improve efficiency, safety, and patient care. Our analysis showed a reduction in man-hours per THA of over 84% when IV TXA is used compared THA performed without IV TXA.

The differences that we discovered dependent on the delivery mechanism of TXA are not conclusive. Facility costs differed very little between IV-TXA and Topical-TXA, yet man-hour costs were doubled; this may be due to the overall health status in the two groups (Topical-TXA was used in patients with significant cardiovascular or thromboembolic history).

Conclusions

When reviewing the cost of transfusion reactions, we were able to identify the number of cases in our data that were affected by this. Two patients (2/1595) had a transfusion reaction that was documented by the blood bank. The national average is 1%–3% depending on what reaction occurs. Transfusion reactions also have associated cost and time consumed in treatment. This is clearly another risk to the patient that can be mitigated if significant reductions in blood transfusions can be accomplished.

The data from this study can be used to identify potential areas of savings and the financial impact of blood transfusion with and without TXA. Our review showed that by using TXA via IV or topically, a 57% and 54% reduction in the process of blood transfusion may be achieved. The combination of savings from the direct and indirect costs can be significant. In addition, Gilbody et al. showed a decrease in hospital stay by 1.2 days when TXA is used in its total joint population, which would also impart savings [2]. This financial savings is not only to the hospital system, but also for the patients, and extremely important due to healthcare changes. 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 three units of blood [11]. In addition, in the event of a transfusion related error, the hospital may not get payment for these services [12].

In conclusion, there is little question that TXA application in total hip arthroplasty can greatly decrease the rate of blood transfusion for that population. The benefits to the patient are the most important application of this medication, but additional benefits can also be appreciated from a cost analysis standpoint as well. Using TXA during primary THA has the potential for important cost savings.

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