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Association of Drain Use in Ankle Arthrodesis With Increased Blood Transfusion Risk: A National Observational Study

Jeffrey Okewunmi, BS[1], Jimmy J. Chan, MD[1], Jashvant Poeran, MD, PhD[1,2], Nicole Zubizarreta, MPH[1,2], Madhu Mazumdar, PhD[1,2], and Ettore Vulcano, MD[1]

Abstract

Background: Closed wound drainage has been extensively studied in the hip and knee arthroplasty literature with equivocal results on its clinical benefits. Although also used in orthopaedic surgeries like ankle arthrodesis and ankle arthroplasty, large-scale data are currently lacking on utilization patterns and real-world effectiveness. We, therefore, aimed to address this research gap in this distinct surgical cohort using national claims data.

Methods: Using the Premier Healthcare claims database from 2006 to 2016, ankle arthrodesis (n=10,085) and ankle arthroplasty (n=4,977) procedures were included. The main effect was drain use, defined by detailed billing descriptions. Outcomes included blood transfusion, 90-day readmission, and length and cost of hospitalization. Mixed-effects models measured associations between drain use and outcomes. Odds ratios (OR, or % change), 95% CIs, and *P* values are reported.

Results: Overall, drains were used in 11% (n=1,074) and 15% (n=755) of ankle arthrodesis and ankle arthroplasty procedures, respectively. Drain use dramatically decreased over the years in both surgery types: from 14% to 6% and 24% to 7% between 2006 and 2016, for arthrodesis and ankle arthroplasty procedures, respectively. After adjustment for relevant covariates, drain use was associated with increased odds of blood transfusion in ankle arthrodesis surgery (OR 1.4, CI 1.1-1.8, $P = .0168$), whereas differences that were statistically but not clinically significant were seen in cost and length of stay. In total ankle arthroplasty, no statistically significant associations were observed between drain use and the selected outcomes.

Conclusion: This is the first national study on drain use in ankle surgery. We found a decrease in use over time. Drain use was associated with higher odds of blood transfusion in ankle arthrodesis patients. Although this negative effect may be mitigated by the rapidly decreasing use of drains, future studies are needed to discern drivers of drain use in this distinct surgical population.

Level of Evidence: Level III, retrospective cohort study

Keywords: arthrodesis, arthroplasty, drains, outcome

Introduction

Closed wound drainage has been long used in orthopaedic surgery because of the proposed benefit of reducing wound hematoma formation. Wound hematomas have been associated with decreased range of motion (ROM), delayed healing, and reoperation.[3,7,8] Drain usage, however, may also increase infection risk by providing a conduit for skin flora into surgical sites and has been associated with an increased risk of blood transfusions.[4,6,13,15,18,19,29] Furthermore, given

[1]Department of Orthopedic Surgery, Icahn School of Medicine at Mount Sinai, New York, NY, USA
[2]Institute for Healthcare Delivery Science, Department of Population Health Science and Policy, Icahn School of Medicine at Mount Sinai, New York, NY, USA

Corresponding Author:
Ettore Vulcano, MD, Columbia University Division of Orthopedic Surgery at Mount Sinai Medical Center, 4302 Alton Road, Simon Building, Suite 220, Miami Beach, FL 33140, USA.
Email: ettorevulcanomd@gmail.com

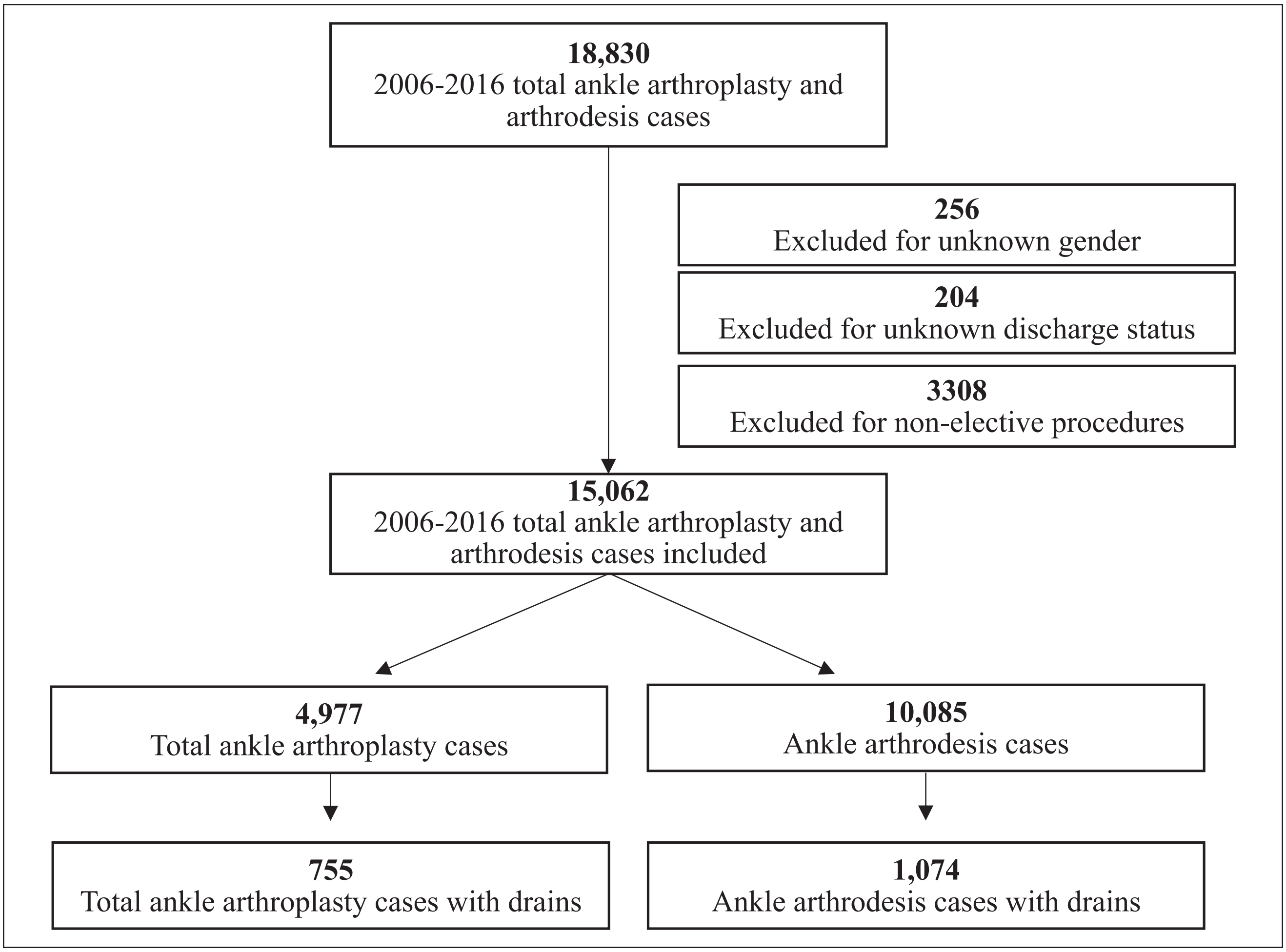

Figure 1. Cohort creation.

the introduction of hemostatic agents like tranexamic acid (TXA), advances in surgical techniques, and improvement in surgical equipment, drain use in foot and ankle surgery has reduced.

There is a plethora of research evaluating drain usage in hip and knee arthroplasty, but there is a paucity of data on the benefits and harms of drains in other orthopaedic settings, including foot and ankle surgery.[6,15,18,19,29] Ankle operations warrant special attention, as the skin around the ankle is often thin and prone to wound complications. Closed wound drainage is seen in total ankle arthroplasty (TAA) and ankle arthrodesis, but research evaluating drain use using large-scale data is yet to be seen.

There is no current consensus on drain use in ankle surgery, and the rate of utilization appears to be changing rapidly. Using national claims data, we, therefore, aimed to (1) describe utilization patterns of drain use in both ankle arthrodesis and TAA and (2) evaluate associations between drain use and outcomes. Specifically, we investigated the need for blood transfusions, length of stay (LOS), cost of hospitalization, and 90-day readmission. Close examination of these outcomes may further provide clues to the utility and effect of drain use. We hypothesize that in our study we will see decreases in drain use over our study period and increases in our outcomes of interest in association with drains.

Materials and Methods

Study Design

This retrospective cohort study used deidentified data from the Premier Healthcare database (Premier Healthcare Solutions, Inc, Charlotte, NC), a national all-payer claims database that contains detailed billing information.[14,20] Diagnoses and procedures were identified using the *International Classification of Diseases, Ninth Revision, Clinical Modification* codes (*ICD-9-CM*) for total ankle arthroplasty (81.11) and ankle arthrodesis (81.56) between 2006 and 2016 (Figure 1). The following exclusion criteria were applied: unknown gender (n=256), unknown discharge status (n=204), and nonelective procedure (n=3,308).

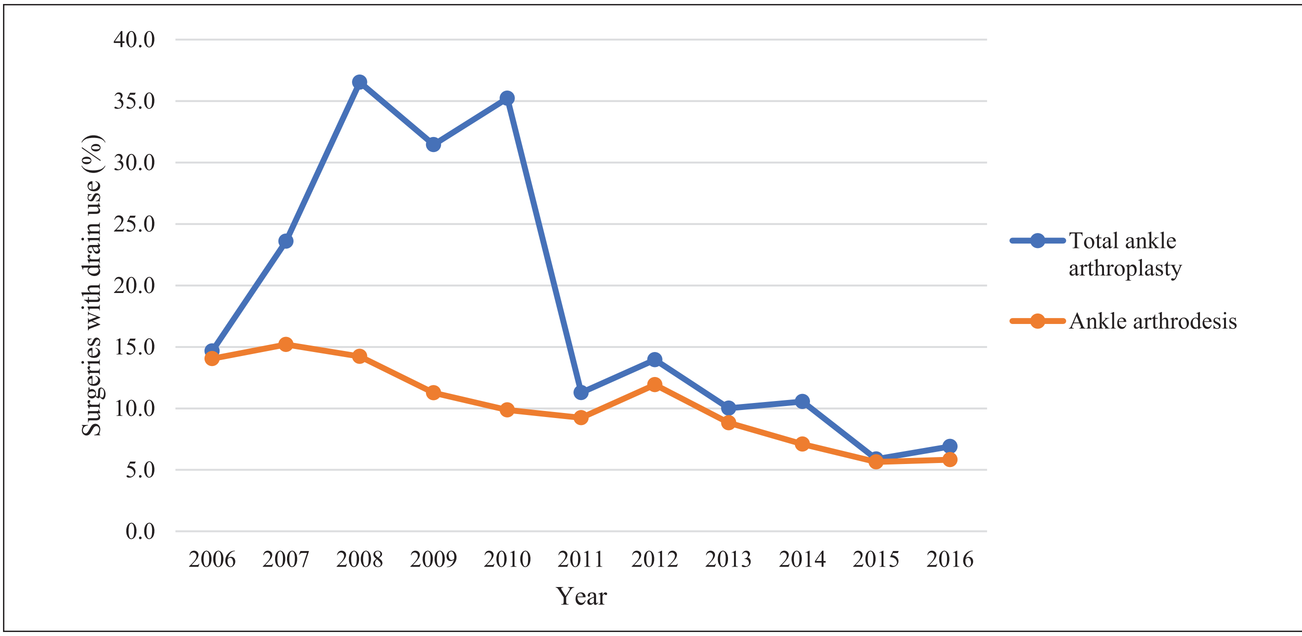

Figure 2. Trends in drain use over time.

Study Variables

All the study variables were defined in an analysis plan, which was specified a priori. The main effect of interest was the use of closed wound drainage, as defined through billing items. The 574 billing items that resulted from a Premier billing chargemaster search for the term "drain" was further narrowed down to a list of 55 items by 2 clinicians separately. The outcomes for this study were the length of stay, cost of hospitalization, need for blood transfusion, and 90-day readmission, each chosen because of their associations with drain use in previous studies. The cost was adjusted for inflation and reported in 2016 US dollars.

For our 2 cohorts, we also obtained variables related to patient demographics, the health care system, the procedure, and comorbidities. Patient demographic variables included patient age, sex, and race (White, Black, other). Health care–related variables were insurance type (commercial, Medicaid, Medicare, Uninsured, and other), hospital location (rural, urban), hospital size (<300, 300-499, ≥500 beds), teaching status, and the annual number of ankle procedures performed per hospital. Procedure-related variables were the year, diagnosis of osteoarthritis, surgeon specialty (orthopaedic foot/ankle surgeon, podiatrist, other/missing), and use of a peripheral nerve block. Comorbidity variables were the Charlson-Deyo Index, history of smoking, and obesity documentation.[21]

Statistical Analysis

Analyses were stratified by surgical categories: TAA and ankle arthrodesis. Univariable associations between drain use, the aforementioned study variables, and outcomes were assessed using standardized differences. Because of the large sample size, univariable group differences are likely to reach statistical significance, so standardized mean differences were used. A standardized mean difference of 0.1 (or 10%) was considered to be a meaningful and significant difference in covariate distribution between groups.[1]

In our multivariable analysis, mixed effects models account for the correlation of care within hospitals and measure the association between drain use and the outcomes.[28] The models were adjusted using the above covariates. Odds ratios or percentage change for continuous outcomes with 95% CIs were reported, and P values <.05 were considered significant. Continuous outcomes used a model with a gamma distribution and a log link function to account for the highly skewed nature of the variable.[17,22] The multivariable analyses were performed using PROC GLIMMIX, and all analyses were done using SAS, version 9.4, statistical software (SAS Institute, Cary, NC).

Results

Trends Analysis

In our arthroplasty cohort, our analysis shows that a higher percentage of arthroplasties used drains from 2006 to 2010 when compared to 2011-2016 (standardized mean difference [SMD] = 0.8009). This trend was similar in arthrodesis cases, where a higher percentage of drains were placed between 2006 and 2012 when compared to 2013-2016 (SMD=0.3361) (Figure 2).

Arthroplasty Baseline Characteristics and Outcomes

In our study, a total of 4,977 patients underwent total ankle arthroplasty, and drains were used in 15% of cases (n=755). Comparing across groups with and without drains placed, there were no significant differences in patient age, gender, race, hospital location, and osteoarthritis history. In our study, however, fewer patients with increased comorbidities received drains (SMD=0.1321). Particularly, smoking was a comorbidity associated with reduced drain placement (SMD=0.2954), while obesity was not. Our study also shows drain use differences associated with insurance status (SMD=0.1390), hospital size (SMD=0.5971), hospital teaching status (SMD=0.1096), hospital procedure volume (SMD=0.6807), and surgeon specialty (SMD=0.9581) (Table 1).

In our univariable analyses, drains were associated with a reduced cost of hospitalization (SMD=0.1712). Our other outcomes of interest, however, did not reach statistical significance in this analysis. In our multivariable analyses, this significance in cost did not persist, as none of our outcomes reached statistical significance (all $P > .05$) (Table 3).

Arthrodesis Baseline Characteristics and Outcomes

In our study, a total of 10,085 patients underwent ankle arthrodesis, and drains were used in 11% (n=1074) of cases. Comparing groups with and without drains after arthrodesis, there were no significant differences in patient age, gender, race, hospital location, and osteoarthritis history. Similar to our findings in arthroplasty cases, our study shows differences in drain usage associated with insurance (SMD=0.1129), hospital size (SMD=0.4899), teaching hospital status (SMD=0.3536), and surgeon specialty (SMD=0.1866) (Table 2). Unlike our findings in arthroplasties, we found no associations between drain placement and total comorbidities, smoking, or obesity.

In our univariable analyses, there were no significant associations with our outcomes of interest. Our multivariable analyses where we account for various variables, however, showed increased blood transfusions (1.4, 95% CI 1.1, 1.8, $P = .0168$), length of stay (4.4%, 95% CI 0.6%, 8.4%, $P = .0477$), and cost of hospitalization (3.7%, 95% CI 0.0%, 7.5%, $P = .0225$) associated with drains (Table 3).

Discussion

This is the first national database study to assess patterns of drain use and outcomes in ankle arthroplasty and arthrodesis. Since 1961 when drains were first proposed in orthopaedic surgery for their surgical benefits, data assessing outcomes have made drain use increasingly controversial.[26] Our study contributes to this discussion, with our findings suggesting that drains should not be used routinely in TAA and ankle arthrodesis.

In our first study objective, we found that drain use in arthrodesis and TAA reduced from 14% to 6% and 24% to 7% over our study period, respectively. This trend may be attributed to both advancements in surgery and the growth of literature surrounding drain use. Although extensively studied in other orthopaedic procedures, there lacks a consensus regarding drain use in ankle surgery.[12,23] Over the span of our study, tranexamic acid (TXA) became more popular in orthopaedic surgery, reducing the theoretical need for drains because of its ability to decrease blood loss and the risk of blood transfusion. Furthermore, more and more studies in the orthopaedic literature, particularly in primary hip and knee arthroplasty, suggest that drains provide minimal added benefit.[6,24,25] Broadly, these studies suggest that drain use generates no significant differences in infection risk, wound hematoma risk, joint function, clinical outcomes, transfusion rates, length of stay, or range of motion.[2,6,26]

The association of drains with an increased odds of blood transfusion in ankle arthrodesis (odds ratio = 1.4, $P = .0168$) is a significant finding in our study and is an association that has been documented in the lower extremity joint literature.[11] Other arthroplasty studies have noted this trend as well, attributing the increased blood loss to the conduit provided from drains.[2,6,29] Increased transfusions pose a clinical risk because of associated sequelae, including increased LOS, hemolytic transfusion reactions, pathogen transmission, immunologic reactions, transfusion-induced coagulopathy, renal failure, and death.[27] Our results allow for a robust assessment of transfusion rates on a national level with more than 10,000 arthrodesis cases, whereas smaller studies may limit the power to detect differences in transfusion rates. Although our study is unable to delineate between open and laparoscopic arthrodesis cases, the association between drain use and transfusions persisted in several sensitivity analyses.

Our study also found associations between drains and increased LOS (4.4%, $P = .0477$) and cost of hospitalization (3.7%, $P = .0225$) in ankle arthrodesis, but no associations in TAAs. In a study by Jiang et al[11] comparing outcomes of arthrodesis and TAA, the authors found no difference in the LOS after each surgery, but an increased cost associated with TAA. By incorporating the variable of drain use, however, we found increases in these variables associated with arthrodesis. Although our study does not account for variations in each surgery, for example, cases that require flaps for closure, we believe that these differences are overcome by our large study sample size. Although the cost difference of drain use appears to be marginal, over 10 weeks in a single hospital, drain use has been associated with a total cost

Table 1. Total Ankle Arthroplasty Univariable Analyses.

	Drain Used (n=755)		No Drain Use (n=4222)		Standardized Difference
	n	% or IQR	n	% or IQR	
Patient demographics					
Age[a]	65	56-71	65	57-71	0.0458
Gender					0.0777
Female	397	52.6	2093	49.6	
Male	358	47.4	2129	50.4	
Race					0.0489
White	655	86.8	3630	86.0	
Black	27	3.6	130	3.1	
Other	73	9.7	462	10.9	
Health care related					
Insurance type					0.1390
Commercial	290	38.4	1599	37.9	
Medicaid	10	1.3	141	3.3	
Medicare	411	54.4	2242	53.1	
Uninsured	2	0.3	20	0.5	
Other	42	5.6	220	5.2	
Hospital location					0.0111
Rural	9	1.2	204	4.8	
Urban	746	98.8	4018	95.2	
Hospital size					0.5971
Small (<300 beds)	161	21.3	1757	41.6	
Medium (300-499 beds)	356	47.2	915	21.7	
Large (≥500 beds)	238	31.5	1550	36.7	
Hospital teaching status					0.1096
Nonteaching	393	52.1	2077	49.2	
Teaching	362	48.0	2145	50.8	
Annual no. of procedures per hospital[a]	18	15-43	17	15-23	0.6807
Procedure related					
Year of procedure					0.8009
2006	11	14.7	64	85.3	
2007	42	23.6	136	76.4	
2008	95	36.5	165	63.5	
2009	106	31.5	231	68.5	
2010	155	35.2	285	64.8	
2011	46	11.3	362	88.7	
2012	79	14.0	487	86.0	
2013	57	10.0	512	90.0	
2014	69	10.6	585	89.4	
2015	45	5.9	720	94.1	
2016	50	6.9	675	93.1	
Osteoarthritis	211	27.9	1137	26.9	0.0228
Surgeon specialty					0.9581
Orthopedics	281	37.2	3093	73.3	
Podiatry	91	12.1	654	15.5	
Other	383	50.7	475	11.3	
Comorbidity related					
Charlson-Deyo Comorbidity Index (categorized)					0.1321
0	510	67.5	2696	63.9	
1	182	24.1	1017	24.1	
2	45	6.0	331	7.8	
2+	18	2.4	178	4.2	
Smoking	102	13.5	1057	25.0	0.2954
Obesity	114	15.1	621	14.7	0.0110

(continued)

Table 1. (continued)

	Drain Used (n=755)		No Drain Use (n=4222)		Standardized Difference
	n	% or IQR	n	% or IQR	
Outcomes					
Length of stay	2	1, 3	2	1, 3	0.0245
Cost of hospitalization[a]	$20520	($16457, $26275)	$21,672	($17693, $27059)	0.1712
Blood transfusion	13	1.72	59	1.40	0.0262
90-d readmission	21	2.78	87	2.06	0.0469

Abbreviation: IQR, interquartile range.
[a]Continuous variables median and IQR reported, instead of n and % respectively.

Table 2. Ankle Arthrodesis Univariable Analyses.

	Drain Used (n=1074)		No Drain Use (n=9011)		Standardized Difference
	n	% or IQR	n	% or IQR	
Patient demographics					
Age[a]	58	48-67	58	48-67	0.0083
Gender					0.0680
Female	485	45.2	4524	50.2	
Male	589	54.8	4487	49.8	
Race					0.0845
White	851	79.2	6861	76.1	
Black	85	7.9	732	8.1	
Other	138	12.8	1418	15.7	
Health care related					
Insurance type					0.1129
Commercial	440	41.0	3457	38.4	
Medicaid	66	6.1	809	9.0	
Medicare	461	42.9	3900	43.33	
Uninsured	19	1.8	147	1.6	
Other	88	8.2	698	7.7	
Hospital location					0.0533
Rural	78	7.3	420	4.7	
Urban	996	92.7	8591	95.4	
Hospital size					0.4899
Small (<300 beds)	265	24.7	2880	32.0	
Medium (300-499 beds)	592	55.1	2901	32.2	
Large (≥500 beds)	217	20.2	3230	35.8	
Hospital teaching status					0.3536
Nonteaching	513	47.8	4193	46.5	
Teaching	561	52.2	4818	53.5	
Annual no. of procedures per hospital[a]	16	14-18	16	14-20	0.2221
Procedure related					
Year of Procedure					0.3361
2006	149	14.0	912	86.0	
2007	153	15.2	854	84.8	
2008	133	14.2	802	85.8	
2009	116	11.3	914	88.7	
2010	101	9.9	922	90.1	
2011	91	9.2	894	90.8	

(continued)

Table 2. (continued)

	Drain Used (n=1074)		No Drain Use (n=9011)		Standardized Difference
	n	% or IQR	n	% or IQR	
2012	119	11.9	879	88.1	
2013	75	8.8	775	91.2	
2014	58	7.1	760	92.9	
2015	41	5.6	685	94.4	
2016	38	5.8	614	94.2	
Osteoarthritis	270	25.1	2004	22.2	0.0683
Surgeon specialty					0.1866
Orthopedics	574	53.4	5566	61.8	
Podiatry	137	12.8	1136	12.6	
Other	363	33.8	2309	25.6	
Comorbidity related					
Charlson-Deyo Comorbidity Index (categorized)					0.0783
0	560	52.1	4510	50.0	
1	260	24.2	2076	23.0	
2	114	10.6	1141	12.7	
2+	140	13.0	1284	14.2	
Smoking	286	26.6	2482	27.5	0.0206
Obesity	243	22.6	1916	21.2	0.0683
Outcomes					
Length of stay	3	2, 3	2	1, 3	0.0576
Cost of hospitalization[a]	$13858	($9602, $20369)	$13055	($8973, $19640)	0.0149
Blood transfusion	88	8.2	554	6.1	0.0793
90-d readmission	21	2.0	184	2.0	0.0062

Abbreviation: IQR, interquartile range.
[a]Continuous variables median and IQR reported, instead of n and % respectively.

Table 3. Multivariable Analyses of Outcomes.[a]

Resource Utilization	Odds Ratio or % Change	*P* Value
Total ankle arthroplasty		
Use of drains (reference = none)		
Length of stay	4.5% (–0.4%, 9.6%)	.0723
Cost of hospitalization	–1.2% (–4.6%, 2.4%)	.5138
Blood transfusion	1.6 (0.7, 3.5)	.2351
Ankle arthrodesis		
Use of drains (reference = none)		
Length of stay	4.4% (0.6%, 8.4%)*	.0477
Cost of hospitalization	3.7% (0.0%, 7.5%)*	.0225
Blood transfusion	1.4 (1.1, 1.8)*	.0168
90-d readmission	0.8 (0.5, 1.4)	.4779

[a]Model is adjusted for age, gender, race, insurance type, hospital location, bed size, teaching status, annual volume of procedures, year of procedure, osteoarthritis, surgeon specialty, Charlson-Deyo Comorbidity Index, smoking, obesity, and interaction term with procedure type and use of a peripheral never block.
*$P < .05$.

of up to $432972.[10] Although there were statistically significant associations with arthrodesis, we found no statistically or clinically significant associations between our outcomes of interest and TAA drain use in our analysis. The absence of findings, however, supports findings in the knee arthroplasty literature of there being no associations between drains and

30-day readmissions.[5] Although not a direct outcome of interest in our study, a recent assessment of 180 TAAs found that drains were associated with increased complications during the first 2 weeks postoperatively.[16] If present in our large-scale study, however, this outcome would likely be present in our outcomes through increased costs, length of stay, and readmission.

There are several limitations to our study that should be recognized. First, this study is retrospective in nature, using observational claims data, so confounding variables such as operative time, preoperative hemoglobin, and postoperative drain protocols were unable to be assessed. We are also unable to verify the reliability of drain billing, which may lead to an underestimation of drains. Moreover, we cannot rule out reverse causation in which patients who are more likely to bleed are more likely to receive drains. However, we expect this to be unlikely because our findings were corroborated in several sensitivity analyses adjusting for observed and unobserved confounding.[9] Additionally, our results suggest that hospital factors, not patient factors, are more important determinants of drain use, further minimizing the role of any reverse causation. Second, while Premier does not represent all hospitals in the United States (20%-25% of all hospitalizations), we believe that findings are generalizable as hospitals from all regions are included. Also, given the robustness of results, we do not expect outcomes to be substantially different in hospitals not included in Premier. Third, our database only draws from inpatient data, and we were only able to track readmissions of patients readmitted to the hospital where the primary surgical procedure took place. This may lead to an underestimation of readmission; however, this should be independent of drain use and is not likely to affect relative effects (ie, odds ratios), thus minimizing the role of this bias in the current study. Fourth, a portion of this study focuses on transfusion rates, and transfusion protocols vary between hospitals. Given that mixed effects models adjust for unspecified hospital-level effects, we expect that some of these adjustments will account for hospital-level protocols, thus minimizing this limitation. Lastly, considerations must be made that database studies can only report on associations and not causation. Therefore, sensitivity analyses were applied to confirm the robustness of results as the risk of confounding is ever-present in observational data.

In conclusion, in this national database study on drain use in ankle surgery, we found a decreasing trend in drain use over 10 years. In ankle arthrodesis, drain use was associated with higher odds for blood transfusion, costs, and LOS. These associations, however, were not found in TAA. Our study suggests that drains should not be used routinely, but future studies are required to discern the drivers of drain use in this distinct surgical population.

Ethical Approval

Ethical approval for this study was waived by the Mount Sinai Hospital Institutional Review Board because this study uses HIPAA-compliant anonymized data (project no. 14-00647).

Declaration of Conflicting Interests

The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article. ICMJE forms for all authors are available online.

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ORCID iDs

Jeffrey Okewunmi, BS, https://orcid.org/0000-0001-9246-1186
Jimmy J. Chan, MD, https://orcid.org/0000-0003-2154-4480

References

1. Austin PC. An introduction to propensity score methods for reducing the effects of confounding in observational studies. *Multivariate Behav Res*. 2011;46(3):399-424. doi:10.1080/00273171.2011.568786
2. Bjerke-Kroll BT, Sculco PK, McLawhorn AS, Christ AB, Gladnick BP, Mayman DJ. The increased total cost associated with post-operative drains in total hip and knee arthroplasty. *J Arthroplasty*. 2014;29(5):895-899. doi:10.1016/j.arth.2013.10.027
3. Butt AJ, McCarthy T, Kelly IP, Glynn T, McCoy G. Sciatic nerve palsy secondary to postoperative haematoma in primary total hip replacement. *J Bone Joint Surg Br*. 2005;87(11):1465-1467. doi:10.1302/0301-620X.87B11.16736
4. Cerise EJ, Pierce W, Diamond DL. Abdominal drains: their role as a source of infection following splenectomy. *Ann Surg*. 1970;171:764-769.
5. Chen JY, Lee WC, Chan HY, Chang PC, Lo NN, Yeo SJ. Drain use in total knee arthroplasty is neither associated with a greater transfusion rate nor a longer hospital stay. *Int Orthop*. 2016;40(12):2505-2509. doi:10.1007/s00264-016-3239-7
6. Chen ZY GY, Chen W, Li X, Zhang YZ. Is wound drainage necessary in hip arthroplasty? A meta-analysis of randomized controlled trials. *Eur J Orthop Surg Traumatol*. 2014;24:939-946.
7. Cheung EV, Sperling JW, Cofield RH. Infection associated with hematoma formation after shoulder arthroplasty. *Clin Orthop Relat Res*. 2008;466(6):1363-1367. doi:10.1007/s11999-008-0226-3
8. Frye BD, Hannon P, Santoni BG, Nydick JA. Drains are not beneficial in primary shoulder arthroplasty. *Orthopedics*. 2019;42:e29-e31.
9. Huang HH, Cagle PJ Jr, Mazumdar M, Poeran J. Statistics in brief: instrumental variable analysis: an underutilized method in orthopaedic research. *Clin Orthop Relat Res*. 2019;477(7):1750-1755. doi:10.1097/CORR.0000000000000729
10. Husted H, Gromov K, Malchau H, Freiberg A, Gebuhr P, Troelsen A. Traditions and myths in hip and knee arthroplasty.

Acta Orthop. 2014;85(6):548-555. doi:10.3109/17453674.2014.971661
11. Jiang JJ, Schipper ON, Whyte N, Koh JL, Toolan BC. Comparison of perioperative complications and hospitalization outcomes after ankle arthrodesis versus total ankle arthroplasty from 2002 to 2011. *Foot Ankle Int*. 2015;36(4):360-368. doi:10.1177/1071100714558511
12. Johns WL, Walley KC, Seedat R, Jackson B 3rd, Boukhemis K, Gonzalez T. Tranexamic acid use in foot and ankle surgery. *Foot Ankle Orthop*. 2020;5(4):2473011420975419. doi:10.1177/2473011420975419
13. Lindahl J, Korkala O, Pammo H, Miettinen A. Bacterial contamination and closed suction drainage in open meniscectomy of the knee. *Ann Chir Gynaecol*. 1993;82(1):51-54.
14. Makadia R, Ryan PB. Transforming the premier perspective hospital database into the observational medical outcomes partnership (OMOP) common data model. *EGEMS (Wash DC)*. 2014;2(1):1110. doi:10.13063/2327-9214.1110
15. Mirzatolooei F TA, Gargari MM. A comparison of the postoperative complications between two drainage methods after total knee arthroplasty. *Arch Bone Jt Surg*. 2014;6:47-51.
16. Moncman TG, Fliegel B, Massaglia J, et al. Comparison between closed suction drainage and no drainage following total ankle arthroplasty. *Foot Ankle Int*. Published online June 20, 2022. doi:10.1177/10711007221099197
17. Moran JL, Solomon PJ; ANZICS Centre for Outcome and Resource Evaluation (CORE) of the Australian and New Zealand Intensive Care Society (ANZICS). A review of statistical estimators for risk-adjusted length of stay: analysis of the Australian and New Zealand Intensive Care Adult Patient Data-Base, 2008-2009. *BMC Med Res Methodol* 2012;12:68. doi:10.1186/1471-2288-12-68
18. Parker MJ, Livingstone V, Clifton R, McKee A. Closed suction surgical wound drainage after orthopaedic surgery. *Cochrane Database Syst Rev*. 2007;3:CD001825. doi:10.1002/14651858.CD001825.pub2
19. Parker MJ, Roberts CP, Hay D. Closed suction drainage for hip and knee arthroplasty. A meta-analysis. *J Bone Joint Surg Am*. 2004;86(6):1146-1152. doi:10.2106/00004623-200406000-00005
20. Premier. Premier Healthcare Database white paper: data that informs and performs. 2017. https://learn.premierinc.com/white-papers/premier-healthcare-database-whitepaper
21. Quan H, Sundararajan V, Halfon P, et al. Coding algorithms for defining comorbidities in ICD-9-CM and ICD-10 administrative data. *Med Care*. 2005;43(11):1130-1139. doi:10.1097/01.mlr.0000182534.19832.83
22. Rascati KL, Smith MJ, Neilands T. Dealing with skewed data: an example using asthma-related costs of medicaid clients. *Clin Ther*. 2001;23(3):481-498. doi:10.1016/s0149-2918(01)80052-7
23. Steinmetz RG, Luick L, Tkach S, et al. Effect of tranexamic acid on wound complications and blood loss in total ankle arthroplasty. *Foot Ankle Int*. 2020;41(9):1117-1121. doi:10.1177/1071100720934889
24. Suarez JC, McNamara CA, Barksdale LC, Calvo C, Szubski CR, Patel PD. Closed suction drainage has no benefits in anterior hip arthroplasty: a prospective, randomized trial. *J Arthroplasty*. 2016;31(9):1954-1958. doi:10.1016/j.arth.2016.02.048
25. Watanabe T, Muneta T, Yagishita K, Hara K, Koga H, Sekiya I. Closed suction drainage is not necessary for total knee arthroplasty: a prospective study on simultaneous bilateral surgeries of a mean follow-up of 5.5 years. *J Arthroplasty*. 2016;31(3):641-645. doi:10.1016/j.arth.2015.10.005
26. Waugh TR, Stinchfield FE. Suction drainage of orthopaedic wounds. *J Bone Joint Surg Am*. 1961;43:939-946.
27. White CC, Eichinger JK, Friedman RJ. Minimizing blood loss and transfusions in total knee arthroplasty. *J Knee Surg*. 2018;31(7):594-599. doi:10.1055/s-0038-1648223
28. Witte JS, Greenland S, Kim LL, Arab L. Multilevel modeling in epidemiology with GLIMMIX. *Epidemiology*. 2000;11(6):684-688. doi:10.1097/00001648-200011000-00012
29. Zhang QD, Guo WS, Zhang Q, Liu ZH, Cheng LM, Li ZR. Comparison between closed suction drainage and nondrainage in total knee arthroplasty: a meta-analysis. *J Arthroplasty*. 2011;26(8):1265-1272. doi:10.1016/j.arth.2011.02.005