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Seokchun Lim
Henry Ford Health, slim2@hfhs.org

Michael Bazydlo
Henry Ford Health, mbazydl1@hfhs.org

Mohamed Macki
Henry Ford Health, mmacki2@hfhs.org

Sameah A. Haider
Henry Ford Health, shaider1@hfhs.org

Lonni Schultz
Henry Ford Health, lschult1@hfhs.org

See next page for additional authors

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Authors

Seokchun Lim, Michael Bazydlo, Mohamed Macki, Sameah A. Haider, Lonni Schultz, David R. Nerenz, Hassan Fadel, Jacob Pawloski, Hsueh-Han Yeh, Paul Park, Ilyas Aleem, Jad Khalil, Richard Easton, Jason M. Schwalb, Muwaffak M. Abdulhak, and Victor Chang

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A Matched Cohort Analysis of Drain Usage in Elective Anterior Cervical Discectomy and Fusion

A Michigan Spine Surgery Improvement Collaborative (MSSIC) Study

Seokchun Lim, MD,[a] Michael Bazydlo, MS,[b] Mohamed Macki, MD,[a] Sameah Haider, MD,[a] Lonni Schultz, PhD,[a,b] David Nerenz, PhD,[a,c] Hassan Fadel, MD,[a] Jacob Pawloski, MD,[a] Hsueh-Han Yeh, PhD,[c] Paul Park, MD,[d] Ilyas Aleem, MD,[e] Jad Khalil, MD,[f] Richard Easton, MD,[f] Jason M. Schwalb, MD,[a] Muwaffak Abdulhak, MD,[a] and Victor Chang, MD[a]

Study Design. This is a retrospective, cohort analysis of multi-institutional database.

Objective. This study was designed to analyze the impact of drain use following elective anterior cervical discectomy and fusion (ACDF) surgeries.

Summary of Background Data. After ACDF, a drain is often placed to prevent postoperative hematoma. However, there has been no high quality evidence to support its use with ACDF despite the theoretical benefits and risks of drain placement.

Methods. The Michigan Spine Surgery Improvement Collaborative database was queried to identify all patients undergoing elective ACDF between February 2014 and October 2019. Cases were divided into two cohorts based on drain use. Propensity-score matching was utilized to adjust for inherent differences between the two cohorts. Measured outcomes included surgical site hematoma, length of stay, surgical site infection, dysphagia, home discharge, readmission within 30 days, and unplanned reoperation.

Results. We identified 7943 patients during the study period. Propensity-score matching yielded 3206 pairs. On univariate analysis of matched cohorts, there were no differences in rate of postoperative hematoma requiring either return to OR or readmission. We noted patients with drains had a higher rate of dysphagia (4.6% *vs.* 6.3%; $P = 0.003$) and had longer hospital stay ($P < 0.001$). On multivariate analysis, drain use was associated with significantly increased length of stay (relative risk 1.23, 95% confidence interval [CI] 1.13–1.34; $P < 0.001$). There were no significant differences in other outcomes measured.

Conclusion. Our analysis demonstrated that drain use is associated with significant longer hospital stay.

Key words: anterior cervical discectomy and fusion, drain, MSSIC, outcomes.

Level of Evidence: 3

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Anterior cervical discectomy and fusion (ACDF) is one of the most common procedures performed by spine surgeons to treat cervical spondylosis. Complication rates with ACDF are low enough that it can be performed even in an outpatient setting.[1,2] However, the surgery is not without risks and some can be devastating such as postoperative hematoma compression of the airway.[3–7]

Some surgeons routinely place a suction drain to address postoperative hematoma. However, the drain tubing may cause pain at the insertion site. Its removal and cutting also result in patient discomfort and anxiety.[8] In rare circumstances, drain removal can cause hematoma formation.[9] Drain placement is also reportedly associated with postoperative surgical site infection (SSI), fever, and blood transfusion following spine surgery.[10–16] In addition, drain placement can extend the Length of stay (LOS) as some surgeons may be reluctant to discharge their patient home with a drain.

Despite the theoretical benefits and risks of drain placement, there has been no adequately powered, randomized controlled study to support its use with ACDF. Limited data from single institution studies by Kogure *et al*[8] and Adogwa

From the [a]From the Department of Neurological Surgery, Henry Ford Hospital, Detroit, MI; [b]Department of Public Health Services, Henry Ford Hospital, Detroit, MI; [c]Center for Health Services Research, Henry Ford Hospital, Detroit, MI; [d]Department of Neurosurgery, University of Michigan, Ann Arbor, MI; [e]Department of Orthopaedics, University of Michigan, Ann Arbor, MI; and [f]Department of Orthopaedics, William Beaumont Hospital, Royal Oak, MI.

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Address correspondence and reprint requests to Victor Chang, MD, Department of Neurological Surgery, Henry Ford Hospital, 2799 West Grand Blvd, Detroit, MI 48202; E-mail: vchang1@hfhs.org

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et al[17] suggest that drain placement following ACDF is not beneficial.

The goal of this study was to query data from the Michigan Spine Surgery Improvement Collaborative (MSSIC) to evaluate the potential effects of drain placement following ACDF. We hypothesize that our analysis will show no benefit with routine drain use following elective ACDF surgeries.

MATERIALS AND METHODS

Study Design

Approval was obtained from our Institutional Review Board (IRB# 10581). Patient consent was not required because the project is a quality improvement initiative. The MSSIC prospectively collects data on elective spine surgeries for degenerative disease from tertiary academic centers, smaller community hospitals, and private practice clinics across the state of Michigan.[18]

The MSSIC registry involves 29 hospitals and 185 orthopedic spine and neurosurgeons in various settings (*i.e.*, academic practice, private practice). Participating hospitals are required to perform a minimum of 200 annual spine surgeries and have active participation from both neurosurgeons and orthopedic surgeons. Support to participating hospitals for data abstraction and quality improvement activities comes from Blue Cross Blue Shield of Michigan (BCBSM) and Blue Care Network (BCN). Hospitals are required to have dedicated data abstractors, and each hospital undergoes a rigorous annual audit.

The MSSIC registry was queried for cases performed from February 2014 through October 2019. Participants included in this study underwent elective ACDF procedures for cervical spondylosis with or without myelopathy. All emergent cases, corpectomies, and total disc replacement cases were excluded.

Both preoperative and intraoperative variables were included in this study cohort for comparison and analysis. Patient age, sex, body mass index (BMI), and race were included. We also tracked history of coronary artery disease (CAD), diabetes, scoliosis, deep venous thrombosis (DVT), chronic obstructive pulmonary disease (COPD), depression based on PHQ-2 (Patient Health Questionnaire), osteoporosis, anticoagulation use, daily opioid use >6 months, and previous spine surgery. Additional variables recorded included independent ambulatory status, private insurance status, baseline Patient-Reported Outcomes Measurement Information System, Physical Function 4-question survey (PROMIS PF-4) score, American Society of Anesthesiology (ASA) class, estimated blood loss (EBL), and the number of levels for surgery.

Outcome measures were complications from surgical site hematoma (SSH) that required operation or resulted in readmission, SSI, dysphagia, readmission (RA) within 30 (30RA) or 90 days (90RA), LOS, and unplanned reoperation. SSH was recorded if the patient returned to the operating room for hematoma evacuation or was readmitted because of postoperative hematoma.

Statistical Analysis

Continuous variables were compared using Student *t* test or Mann–Whitney *U* test or *t* test based on the normality of variables. Pearson χ^2 test or Fischer exact test was used for categorical variables. Given the retrospective nature of the study, the baseline difference was adjusted using propensity score-matching analysis. Propensity score matching is a widely established method for adjusting baseline difference for non-randomized, cohort studies.[19–21]

Briefly, a propensity score for drain placement was derived using a nonparsimonious logistic regression model. The variables accounted for in the regression model include age, BMI, CAD, ASA class, operative duration, and number of levels fused. We used 1:1, nearest neighbor, and without replacement matching algorithm to ensure that one drain case was matched to one control case (no drain). Each matched set was within the designated limit (caliper width) and all cases outside of the limit were discarded.[22] This process yielded 3206 well-matched pairs. McNemar exact test for categorical variables and Wilcoxon Signed Ranks test or paired *t* test for continuous variables were used. With the propensity score-matched dataset, multivariable generalized estimating equation (GEE) models that specified a Poisson error distribution and log link function were used to estimate the impact of drain placement following ACDF procedures on the outcomes of interest while adjusting for the variables included in the propensity score matching. This type of model is similar to a generalized linear model such as Poisson or logistic regression but also considers the potential latent effects that vary from hospital to hospital.

We used R 3.52 (R Foundation for Statistical Computing, Vienna, Austria) and SAS (SAS Institute, Inc., Cary, NC) for our analysis.

RESULTS

Unadjusted Dataset

We initially captured 8283 patients, and 340 patients were excluded due to missing variables. A total of 7943 cases were included in our analysis. Of the 7943 patients included in this study, 3830 were in the drain cohort and 4113 in the no drain cohort. Patients who had a drain were more likely to be older and of non-white race. The drain cohort also had a higher proportion of patients with CAD history, depression, osteoporosis, advanced ASA class, chronic opioid use, and lower PROMIS baseline. Compared with controls, there were more levels for surgery, longer operative duration, and higher EBL (Table 1).

Propensity-Matching Analyses

Propensity-score matching yielded 3206 well-matched pairs (Figure 1). After matching, we observed reductions in differences seen in the unmatched cohorts. Specifically, matching eliminated differences in age, history of CAD, daily opioid use >6 months prior to surgery, independent ambulation,

TABLE 1. Unmatched Univariate Analysis of Pre-/Intra-operative Variables

Variables	No Drain (n = 4113)		Drain (n = 3830)		*P*-Value
	n	%	n	%	
*Age	54.7 ± 11.1		55.7 ± 11.0		<0.001
BMI	30.5 ± 6.8		30.7 ± 6.7		0.252
Gender					
Male	1955	47.5%	1794	46.8%	0.531
Female	2158	52.5%	2036	53.2%	
*Race					<0.001
White	2374	57.7%	1811	47.3%	
Black	230	5.6%	257	6.7%	
Other	162	3.9%	123	3.2%	
Private insurance	2318	56.4%	2148	56.1%	0.806
Diabetes	794	19.3%	764	19.9%	0.478
Scolioisis	376	9.1%	329	8.6%	0.392
Hx DVT	209	5.1%	214	5.6%	0.319
*CAD	366	8.9%	404	10.5%	0.013
Hx COPD	342	8.3%	346	9.0%	0.281
*Depression	1026	24.9%	735	19.2%	0.011
*Osteoporosis	298	7.2%	235	6.1%	0.044
Current smoking	618	15.0%	552	14.4%	0.051
Anticoagulant use	206	5.0%	226	5.9%	0.088
*Preop daily opioid use >6 months	701	17.0%	640	16.7%	0.017
*Independent ambulation	3721	90.5%	3389	88.5%	0.003
Previous spine surgery	1426	34.7%	1403	36.6%	0.071
*PROMIS baseline	37.0 ± 7.1		36.3 ± 6.9		<0.001
*ASA class >2	2008	48.8%	1965	51.3%	0.027
*Operative durations, hrs†	1.5 (1.1, 2)		1.6 (1.1, 2.2)		<0.001
No of levels*					
1	2116	51.4%	1389	36.3%	<0.001
2	1498	36.4%	1507	39.3%	
3+	497	12.1%	928	24.2%	
*EBL, mL†	30 (20, 50)		50 (24, 75)		<0.001

**Denotes statistical significance, P < 0.05.*

†Expressed in median (25th, 75th percentile), otherwise numerical variables are noted as mean ± standard deviation.

ASA indicates American Association of Anesthesiology; BMI, body mass index; CAD, coronary artery disease; COPD, chronic obstructive pulmonary disease; DVT, deep venous thrombosis; EBL, estimated blood loss; PROMIS, Patient-Reported Outcomes Measurement Information System.

ASA class, operative duration, and the number of levels fused during surgery between two cohorts. However, some differences persisted. The propensity-matched drain cohort still had more non-Caucasian patients with scoliosis, depression, osteoporosis, history of spine surgery, lower PROMIS score, previous spine surgery, and higher EBL (Table 2).

Comparing outcomes, patients in the drain cohort experienced more dysphagia and longer hospital stay compared with control (Table 3). Our retrospective assessment did not allow application of subjective dysphagia measures. We identified clinically significant dysphagia using indirect measures including alteration of diet, change to NPO status, or placement of a temporary feeding tube as recommended by a formal swallowing study. Using these measures there was a greater incidence of dysphagia in the drain group when compared with the control group.

Regression Analysis

Following multivariable regression analysis, we observed that drain use was associated with longer LOS (relative risk [RR] 1.23, 95% confidence interval [CI] 1.13–1.34; $P < 0.001$). Regression analysis was not possible for SSH given the small number of outcomes. There were no differences noted in other measured outcomes between the two cohorts (Table 4).

DISCUSSION

In our study, we identified 7943 patients who underwent elective ACDF procedure with 6412 patients being included

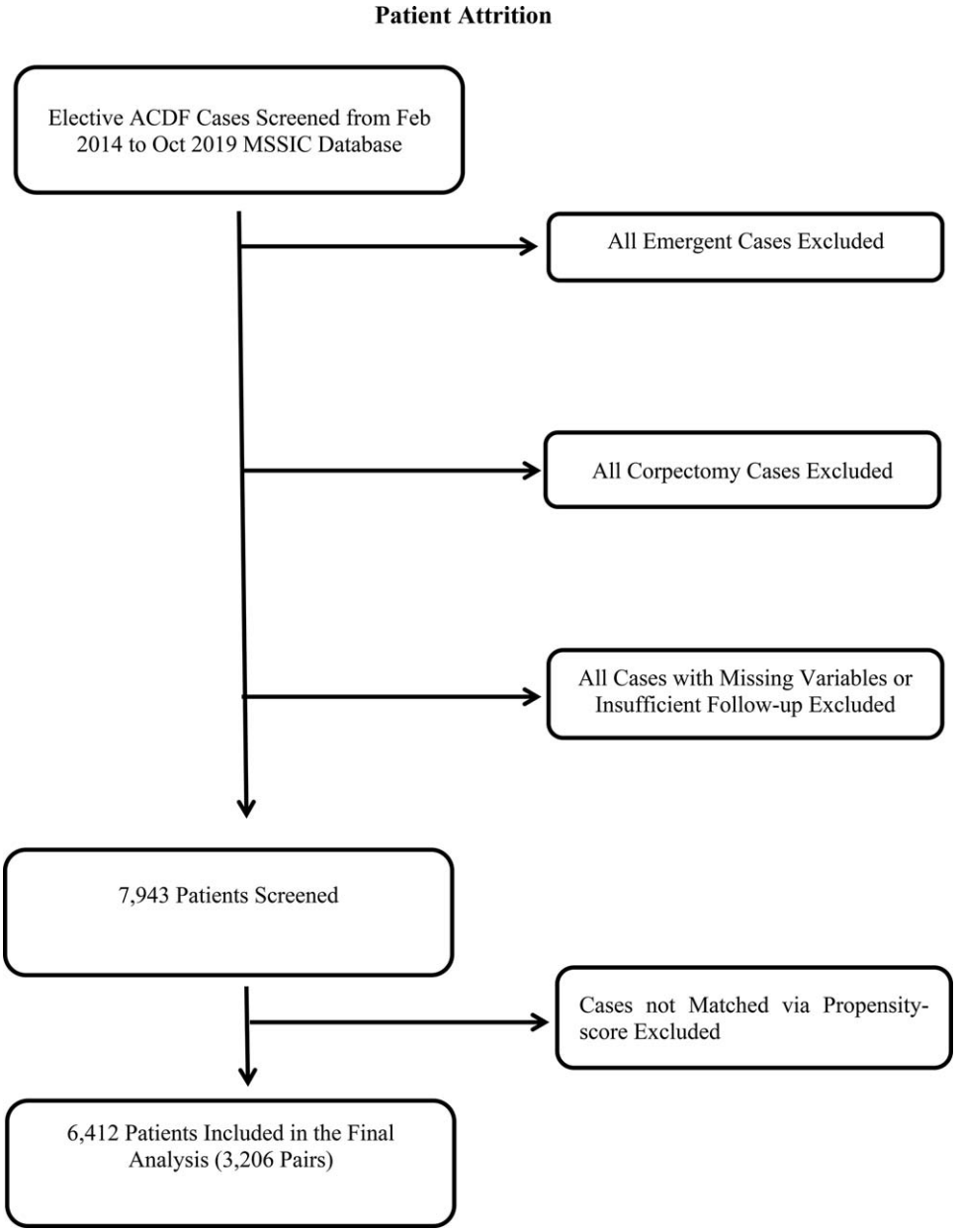

Figure 1. Patient attrition diagram.

in the final analysis after propensity matching. Our propensity score matched, and multivariate analysis demonstrated an increased risk of longer LOS (relative risk 1.23, 95% CI 1.13–1.34; $P < 0.001$). Another significant finding in our study is that drain placement was not associated with critical postoperative hematoma requiring readmission or reoperation. While most spine surgeons achieve adequate hemostasis at the time of closure after ACDF, delayed postoperative hematoma is a significant concern as this is a potentially life-threatening complication. To our knowledge, this is the first multi-institutional analysis on the impact of drain use following ACDF.

Subfascial drains are frequently used by surgeons following ACDF to reduce postoperative complications such as life-threatening hematoma that can compromise a patient's airway. Drain placement is intended to prevent such complications which are associated with significant morbidity and higher healthcare cost. However, the benefit of drain placement is controversial since the reported rate of this serious complication is relatively low in the 1% range.[23] The role of drains in ACDF has been investigated by a few studies although most of them are underpowered. In Japan, Kogure *et al*[8] performed a randomized controlled trial on 43 patients undergoing single level ACDF. Drain placement did not make a difference in postoperative prevertebral space volume nor any other postoperative complication. However, the study was underpowered with insufficient sample size to reveal potential benefit of or harm from drain placement. Several retrospective studies have assessed the role of drain in ACDF surgeries, although it is difficult to

TABLE 2. Matched Univariate Analysis of Pre-/Intra-operative Variables

Variables	No Drain (n = 3206)		Drain (n = 3206)		*P*-Value
	n	%	n	%	
Age	55.0 ± 10.9		55.3 ± 11.1		0.396
BMI	30.5 ± 6.9		30.8 ± 6.8		0.116
Gender					
Male	1518	47.3%	1499	46.8%	0.626
Female	1688	52.7%	1707	53.2%	
*Race					0.007
White	1879	58.6%	1540	48.0%	
Black	194	6.1%	221	6.9%	
Other	127	4.0%	108	3.4%	
Private Insurance	1770	55.2%	1815	56.6%	0.258
Diabetes	646	20.1%	646	20.1%	>0.999
*Scoliosis	311	9.7%	264	8.2%	0.040
Hx DVT	165	5.1%	184	5.7%	0.298
CAD	308	9.6%	308	9.6%	>0.999
Hx COPD	295	9.2%	287	9.0%	0.626
*Depression	832	26.0%	628	19.6%	0.002
*Osteoporosis	253	7.9%	195	6.1%	0.004
Current smoking	497	15.5%	472	14.7%	0.132
Anticoagulant use	168	5.2%	189	5.9%	0.291
Preop daily opioid use >6 mo	575	17.9%	534	16.7%	0.299
Independent ambulation	2884	90.0%	2884	90.0%	>0.999
Previous spine surgery	1111	34.7%	1185	37.0%	0.039
*PROMIS baseline	37.0 ± 7.1		36.5 ± 6.9		0.018
ASA class >2	1626	50.7%	1626	50.7%	>0.999
Operative durations†	1.5 (1.1, 2.1)	1.6 (1.1, 2.1)	>0.999	1.6 (1.1, 2.1)	>0.999
No. of levels					
1	1338	41.7%	1338	41.7%	
2	1391	43.4%	1391	43.4%	
3+	477	14.9%	477	14.9%	
*EBL, mL†	30 (20, 50)		40 (20, 60)		<0.001

**Denotes statistical significance, P < 0.05.*

†Expressed in median (25th, 75th percentile), otherwise numerical variables are noted as mean ± standard deviation.

ASA indicates American Association of Anesthesiology; BMI, body mass index; CAD, coronary artery disease; COPD, chronic obstructive pulmonary disease; DVT, deep venous thrombosis; EBL, estimated blood loss; PROMIS, Patient-Reported Outcomes Measurement Information System.

reach a generalizable conclusion based on the low levels of evidence.[17,24,25]

A retrospective study by Pryor *et al*[24] analyzed 127 patients undergoing ACDF where drain placement was not associated with postoperative outcome including dysphagia, infection, or hematoma. However, their results are confounded with significant surgeon bias where two surgeons routinely placed drains whereas the other two did not. Similarly, Poorman *et al*[25] retrospectively collected data from patients undergoing one- or two-level ACDF. However, they reported patients with drain placement had longer operative duration (101 min *vs.* 69 min) and higher EBL (69.7 cm^3 *vs.* 29.1 cm^3; $P < 0.001$) which raises the possibility of unidentified bias. More recently, Adogwa *et al*[17] investigated the same subject focusing on multi-level ACDF cases. The authors conducted a retrospective cohort study of 321 patients where drain use was associated with increased postoperative transfusion and longer hospital stay. However, this study did not include any unplanned reoperation case, which would have been the major consequence of critical SSH. Previous findings are from mostly single institution studies with potential surgeon-preference bias. Also, the number of patients included in previous studies appears to be too low to reveal any potential underlying differences in complication rates (approximately 1%).

In our study, increased LOS could be explained by outpatient ACDF surgeries where patients were discharged on the same day of surgery without drain placement. Outpatient ACDF surgeries have gained popularity with multiple studies validating their safety and cost-effectiveness.[1,2]

TABLE 3. Matched Univariate Analysis of Outcomes

Variables	No Drain (n = 3206)		Drain (n = 3206)		*P*-Value
	n	%	n	%	
SSH	9	0.3%	6	0.2%	0.607
*LOS					
0–1	2451	76.5%	1837	57.3%	<0.001
2–3	589	18.4%	1102	34.4%	
4+	165	5.1%	266	8.3%	
SSI	14	0.4%	17	0.5%	0.570
*Dysphagia	148	4.6%	202	6.3%	0.003
Discharge Home	3102	96.8%	3081	96.1%	0.116
30RA	83	2.6%	104	3.2%	0.100
Return to OR	117	3.6%	92	2.9%	0.092

*Denotes statistical significance, $P < 0.05$.

30RA indicates 30-day readmission; LOS, length of stay; SSH, surgical site hematoma; SSI, surgical site infection.

TABLE 4. Regression Analysis Results

Variables	OR/RR (95% CI)	*P*-Value
*LOS†	1.23 (1.13, 1.34)	<0.001
SSI	1.28 (0.60, 2.73)	0.525
Dysphagia	1.29 (0.92, 1.82)	0.145
30RA	1.28 (0.96, 1.72)	0.091
Return to OR	0.76 (0.57, 1.02)	0.072

*Denotes statistical significance, $P < 0.05$.

†Noted as relative risk.

30RA indicates 30-day readmission; CI, confidence interval; LOS, length of stay; OR, odds ratio; SSI, surgical site infection.

A side from economics, it is also well established that shorter LOS is associated with improved outcomes following various surgical procedures which likely convinced surgeons to avoid intraoperative drain placement. Also, spine surgeons may not feel comfortable discharging patients to home with drains. These patients could have been admitted for longer periods to monitor drain output and to await drain removal.

A small case series by O'Neal showed up to 35% of hematomas after ACDF occurred at several days after surgery.[26] Intraoperative drain placement is routinely performed by many spine surgeons to prevent the formation of hematomas from the deep surgical cavity as these can potentially cause catastrophic outcome. However, our multi-institutional cohort study demonstrated that drain use was not protective of complications occurring from postoperative hematoma. There was no significant difference or trend in SSH or reoperation regardless of the number of levels operated.

Given that this is a retrospective study the potential exists for hidden bias not accounted for in our methodology. In addition, factors outside of what was accounted for on propensity score matching could also introduce potential bias between the two cohorts and would not be equivalent to one to one randomization. Additionally, the nature of our database does not allow the granularity to capture all the factors the go into decision making for drain placement. Despite these limitations, we still believe our findings to be worthwhile.

Additionally, given the wide heterogeneity of practice environments and patient population we feel that the results from this study are widely generalizable although there may be some idiosyncrasies of the demographics of the state of Michigan which are not generalizable to all populations.

CONCLUSION

Our study does not show a clear protective benefit of drain usage for routine ACDF. There are some associations between drain usage and slightly longer length of stay, but we do not see any clear evidence to support or refute the routine use of drains for ACDF.

➢ Key Points

- ❑ Drain usage did not result in decreased postoperative hematoma requiring readmission or return to OR.
- ❑ There is no clear benefit with drain usage after ACDF surgery.
- ❑ Drain usage was associated with longer hospital stay.

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