MINIMALLY INVASIVE VERSUS OPEN LUMBAR FUSION: A COMPARISON OF BLOOD LOSS, SURGICAL COMPLICATIONS, AND HOSPITAL COURSE

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ABSTRACT

Background: Perioperative blood loss is a frequent concern in spine surgery and often necessitates the use of allogeneic transfusion. Minimally invasive technique (MIS) is an option that minimizes surgical trauma and therefore intra-operative bleeding. The purpose of this study is to evaluate the blood loss, surgical complications, and duration of inpatient hospitalization in patients undergoing open posterolateral lumbar fusion (PLF), open posterior lumbar interbody fusion (PLIF) with PLF, or MIS transforaminal lumbar interbody fusion (MIS TLIF).

Methods: Operative reports and perioperative data of patients undergoing single-level, primary open PLF (n=41), open PLIF/PLF (n=42), and MIS TLIF (n=71) were retrospectively evaluated. Patient demographics, operative blood loss, use of transfusion products, complications, and length of stay were tabulated. Patient data was controlled for age, BMI, and gender for statistical analysis.

Results: Patients undergoing open PLF and open PLIF/PLF respectively experienced a significantly higher blood loss ($p<0.001$), higher volume of blood transfusion ($p<0.001$), higher volume of cell saver transfusion ($p<0.001$), and more surgical complications (dural injury, wound infections, screw malposition) ($p=0.02$) than those undergoing MIS TLIF. There was no statistically significant difference in duration of hospital stay ($p=0.11$).

Conclusions: MIS TLIF provides interbody fusion with less intraoperative blood loss and subsequently a lower transfusion rate compared to open techniques, but this did not influence length of hospital stay. MIS TLIF is at least as safe as open techniques with respect to dural tear, wound infection, and screw placement.

Level of Evidence: Level III, Therapeutic

INTRODUCTION

Lumbar spondylolisthesis with stenosis is a common ailment causing back pain, radiculopathy, and/or neurogenic claudication[1]. Patients who fail non-operative treatment are often treated surgically with decompression of the neural elements and stabilization with spinal fusion when indicated[2]. Many surgical techniques have been used to achieve this, most commonly via laminectomy and posterolateral instrumented fusion (PLF), which allows for direct decompression of the neural elements and arthrodesis across the posterior elements[3]. Posterior lumbar interbody fusion (PLIF), first described by Cloward and colleagues in 1953, is an alternate procedure that provides three-column stabilization and, in some cases, indirect decompression of the neural elements through restoration of disk space height[4]. PLIF has been shown to provide an increase in lumbar lordosis, high fusion rates, and overall excellent clinical outcomes[5]. In patients with spondylolytic spondylolisthesis, PLIF combined with PLF (PLIF/ PLF) allows for structural support along with direct decompression and has been reported to have a greater reduction in listheses, a lower complication rate, and more excellent results compared to PLF alone[6].

Transforaminal lumbar interbody fusion (TLIF), first described in 1982 by Harms and Rolinger, is an alternative to PLIF that implements a unilateral approach to the disc space and minimizes retraction of the neural elements[7]. Similar to PLIF, TLIF provides decompression, allows for correction of anterolisthesis, and achieves a circumferential fusion. Compared to PLIF, TLIF is associated with similar fusion rates and restoration of sagittal

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Table 1: Patient Baseline Characteristics

	Open PLF	*Open PLIF/PLF*	*MIS TLIF*	*p value*
Age (y)	61.5 (30-89, 14.1)	54.6 (22-86, 15.3)	58.6 (26-85, 11.8)	0.066
Gender (% male)	39.0	40.5	39.4	0.99
BMI (kg/ m2)	27.6 (16.3-39.6, 4.9)	27.4 (20.4-45.3, 6.3)	27.4 (17.3-39.4, 4.6)	0.99

*Range and standard deviation listed in parenthesis

balance; however, TLIF is also technically demanding and may be associated with increased operating time, blood loss, and postoperative complications[3].

With advances in surgical technique and instrumentation, minimally invasive surgical techniques (MIS) have been developed to perform decompression and interbody fusion. MIS for interbody fusion has been associated with less blood loss, less need for transfusion in the post-operative period, and earlier ambulation. However, MIS procedures are more technically demanding than open procedures and have reportedly been associated with higher complication rates[8].

Perioperative blood loss is a frequent concern in spine surgery and often necessitates the use of allogeneic transfusion. Blood transfusion carries several well-known risks, including the transmission of blood-borne infections, transfusion-related immunomodulation, febrile reactions, and acute lung injury[9,10]. The need for blood product transfusion may be minimized with careful patient selection and improved surgical techniques. The purpose of this study is to evaluate the blood loss, need for transfusion, surgical complications, and duration of inpatient hospitalization of patients undergoing open PLF, open PLIF/PLF, and MIS TLIF.

MATERIAL AND METHODS

After Institutional Review Board (IRB) approval, we performed a retrospective cohort study using prospectively-collected data from the electronic medical record. Operative case logs were reviewed to query all patients undergoing primary, single-level MIS TLIF at the University of Miami Hospital and Jackson Memorial Hospital by four surgeons (ADL, SV, MYW, SKW) from January 2010 through December 2012. Separate cohorts during the same time frame were obtained for primary, single-level open PLF by three surgeons (BAG, NHL, SKW) and open PLIF/PLF by two surgeons (BAG, NHL). Cases were consecutive and reflected each surgeon's surgical preference. Patients undergoing a combined anterior and posterior approach or a revision surgery were not included.

The electronic and paper records for the open PLF (n=41), open PLIF/PLF (n=42), and MIS TLIF (n=71) groups were reviewed. No patients had a history of a bleeding disorder.

Operative reports, discharge summaries, pre-operative and post-operative notes, and anesthesia records were reviewed. Patient demographics and perioperative datapoints were tabulated. Specifically, operative blood loss, amount of perioperative product transfused (packed red blood cells and cell saver), specific complications (dural injuries, wound complications, screw malposition, neurological deterioration), and length of stay were recorded. Anesthesia records were considered the most accurate for blood loss during the procedure. Estimates for blood loss were made from recording blood in the suction/ cell saver canisters and subtracting total irrigation used during the case. Cell saver and packed red blood cell transfused were recorded from anesthesia records as well. Total product transfused was defined as the some of cell saver and packed red blood cells transfused. Other outcomes (i.e. radiculopathies, motor deficits, paresthesias) or complications after discharge were not recorded in the outpatient setting.

Statistical comparisons between the three groups were made using the one-way analysis of variance test for continuous variables, and statistical significance was defined as $p<0.05$. The Wald test was implemented for comparisons between MIS TLIF to all open procedures (open PLF and open PLIF/PLF). Age, BMI, and gender were controlled for this analysis. All analysis was conducted using *R* statistical software[11].

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RESULTS

There was no statistically significant difference for age, gender, or BMI amongst the open PLF, open PLIF/PLF, and MIS TLIF groups (Table 1). Blood loss and transfusion varied considerably amongst cohorts (Table 2). Open PLF and open PLIF/PLF were associated with significantly more blood loss (313 cc and 514 cc respectively) than the MIS TLIF group (136 cc). Subsequently, a blood product transfusion (including blood products or cell saver) was more likely to be administered and

Table 2: Surgical Outcomes

	Open PLF	Open PLIF/PLF	MIS TLIF	p value
Estimated Blood Loss (cc)	313 (50-100, 189)	514 (200-1350, 250)	136 (25-600, 108)	<0.001
Transfused? (%)*	61.0	74.0	4.2	<0.001
Total Product Transfused (cc)*	163 (0-720, 193)	275 (0-905, 259)	6 (0-200, 30.6)	<0.001
Blood Transfused? (%)	29.0	42.9	0.0	<0.001
Blood Transfused (cc)	97 (0-500, 175)	146 (0-500,191)	0 (0)	<0.001
Cell Saver Transfused? (%)	39.0	57.1	4.2	<0.001
Cell Saver Transfused (cc)	67 (0-470, 104)	135 (0-540, 146)	6 (0-200, 30.6)	<0.001
Length of Stay (d)	4.3 (2-11, 1.5)	4.8 (2-16, 2.5)	4.1 (2-10, 1.4)	0.11
Complications** (%)	14.6	9.5	1.4	0.02

*Total product transfused is the sum of blood products and cell saver
**Includes dural injury, wound infection, and screw placement.
***Range and standard deviation listed in paranthesis

Table 3: Surgical Complications

	Open PLF	Open PLIF/PLF	MIS TLIF
Dural Tear	3	3	0
Wound Infection	2	1	1
Screw Placement	1	0	0

using greater amounts with open PLF (61.0%, 163 cc) and (74.0%, 275 cc) than the MIS TLIF (4.2%, 6 cc). In particular, packed red blood cells were transfused in 29.0% (97 cc) of cases in the open PLF group, 42.9% (146 cc) in the open PLIF/PLF group, and never in the open MIS TLIF group. Intra-operative cell saver was used primarily or as an adjunct in several cases as well. Open PLF utilized cell saver in 39.0% (67 cc) of cases, open PLIF/PLF in 57.1% (135 cc) of cases, and MIS TLIF in 4.2% (6 cc) of cases. After controlling for age, BMI, and gender, patients with open PLF were more likely to have greater blood loss (Odds Ratio [OR] = 2.4, 95% Confidence Interval [CI] 1.9-3.1), a blood transfusion (OR= 67.9, 95% CI 16.8-395.6), and cell saver transfusion (OR = 16.7, 95% CI 4.8-80.8) compared to those undergoing MIS TLIF. Similarly, patients with open PLIF/PLF were more likely to have greater blood loss (OR = 4.2, 95% CI 3.3-5.3), a blood transfusion (OR= 257.1, 95% CI 50.6-1949.7), and cell saver transfusion (OR = 64.7, 95% CI 16.0-368.7) compared to those undergoing MIS TLIF.

Overall, there were significantly more complications (dural injuries, wound complications, screw malposition) associated with open PLF (14.6%) and open PLIF/PLF (9.5%) compared to MIS TLIF (1.4%) (Table 3). Adjusting for age, gender, and BMI, open PLF was associated with 14.4 (95% CI = 2.6-174.1) times more complications than MIS TLIF, and open PLIF/ PLF was associated with 5.5 (95% CI = 0.8-72.2) times more complications than MIS TLIF. In the open PLF cohort, three patients experienced a dural injury intra-operatively, all of which were repaired without complication. In addition, two patients developed deep post-operative wound infections treated with an incision and debridement followed by intravenous antibiotics, and one other patient was found to have aberrant screw placement with post-operative neurological deficits requiring revision. In the open PLIF/ PLF group, one patient had a post-operative wound infection requiring an incision and debridement and intravenous antibiotics. Three patients also had dural tears, two of which were found intra-operatively and repaired, and one diagnosed post-operatively and definitely treated with a lumbar drain. One patient who underwent a MIS TLIF experienced a superficial wound infection on post-operative day 5 and was treated with intravenous and later oral antibiotics; there were no infections requiring surgical debridement. There were no dural tears in patients who underwent MIS TLIF. No patients in any cohorts (except for the aberrant screw complication of the open PLF cohort) experienced gross neurological deterioration in the immediate post-operative period, and no patients experienced any other medical complications. There was also a non-significant trend (p= 0.11) towards greater lengths of stay with open PLF (4.3 days) and open PLIF/ PLF (4.8 days) compared to the MIS TLIF group (4.1 days).

DISCUSSION

Lumbar fusion can be performed via several techniques, including PLF, PLIF, and TLIF. The advent of minimally invasive techniques provides an additional option that seeks to minimize surgical trauma caused by exposing the spine. Our results indicate that MIS TLIF can be performed with less intraoperative blood loss, lower blood product transfusion rates, and fewer

surgical complications than the traditional open PLF and open PLIF/ PLF procedures.

Recent reviews of the literature have been inconclusive regarding the perioperative outcomes of PLIF and PLF. One study demonstrated similar operative times and blood loss between the groups with a shorter length of stay associated with the PLIF group[12]. A recent meta-analysis by Liu et. al examined four randomized clinical trials and five comparative observational studies. The authors concluded that there was no difference between PLF and PLIF in regards to blood loss, complications, or operating time[13]. Comparisons between TLIF and PLIF have been inconclusive in the literature as well. Recent retrospective reviews have claimed that TLIF is generally associated with shorter operative times, less blood loss, and equivocal findings in regards to complications[3,14]. Studies regarding MIS techniques compared to open techniques have been more homogenous in their results. Dhall et al. retrospectively compared MIS TLIF and open TLIF and demonstrated a lower blood loss (194 cc vs. 505 cc), shorter length of stay (3.0 days vs. 5.5 days), and a higher rate of hardware- related complications with MIS TLIF[15]. Other studies have also demonstrated a lower blood loss and shorter length of stay with MIS TLIF when compared to open TLIF.[16,17]. Our findings are most in accordance with the literature. The increased blood loss associated with the open PLIF/PLF is expected given greater dissection and more surgical procedures being performed; however, there was a slightly higher complication rate with open PLF compared to open PLIF/PLF. With a limited cohort size, this difference may be a result of type I error.

The additional costs associated with blood product transfusion should also be considered. In a recent cost-benefit outcome study, the average cost of cell saver was $512 per patient transfusion and $250 per unit of allogeneic blood replaced[18]. In another study examining the use of cell saver in single-level spine surgery, the authors concluded that with cell saver there was an additional cost of $722 per surgery and no significant reduction in blood loss or need for transfusion[19]. A systematic review by Elgafy et al determined that the rate of blood transfusion with spinal fusion (including primary and revision procedures, anterior/posterior/combined approaches, and multi-level fusions) may be as high as 50 -81%. The authors also noted that there is weak evidence to support the use of agents to reduce intra-operative blood loss, in particular cell saver, recombinant factor VIIa, activated growth factor platelet gel, or normovolemic hemodilution[20]. As such, the surgical technique is an important variable in minimizing the morbidity and cost associated with blood product transfusion.

There are limitations to this study. It is a retrospective review and patient treatments were not randomized. Surgeries were conducted by six surgeons across two hospitals. Our outcomes were limited to only length of stay, blood loss and transfusion, and certain complications during hospitalization. We chose to focus on four specific complications because we felt that they best represented potential differences between open and MIS techniques. Neither long-term outcome measures nor radiographic data were studied past the date of discharge from the hospital. However, the goal of this study was to examine the early post- operative outcomes, in particular blood loss and complications during hospitalization, from the listed procedures. Our study was properly controlled based on age, BMI, and gender, and all surgeries were single-level, primary fusions to minimize confounding variables.

Our results indicate that MIS TLIF has less blood loss, blood product transfusion, wound complications, dural injury, and screw malposition when compared to open procedures. With the lack of long-term clinical and radiographic data, it is not possible to state whether one procedure is superior to another, and this decision should be based on surgeon preference and experience. The data indicate that MIS TLIF is at least as safe as open PLF and open PLIF/PLF. These findings may help surgeons in planning their surgical approach in patients who may be candidates for lumbar decompression with fusion, and underscores the importance of learning and teaching MIS techniques during surgical training.

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