Incidence of Major Vascular Injuries with Extreme Lateral Interbody Fusion (XLIF)

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**ABSTRACT**

**Background:** Extreme lateral interbody fusions (XLIF) and minimally invasive (MI) XLIF theoretically offer wide access to the lumbar disc space. The theoretical advantages of XLIF include; minimally disturbing surrounding structures (e.g. neural, vascular, soft-tissue), while offering stability. In addition to the well-known increased frequency of neurological deficits attributed to XLIF, here we explored how often major vascular injuries occur with XLIF/MI XLIF procedures.

**Methods:** In 13 XLIF/MI XLIF studies, we evaluated the frequency of major vascular injuries.

**Results:** The studies citing the different frequencies of vascular injuries associated with XLIF/MI XLIF were broken down into three categories. Of the 5 small and larger case series, involving a total of 6,732 patients (e.g. range of 12 to 4,607 patients/study), the incidence of vascular injuries ranged from 0% (3 studies) up to 0.4%. Three case reports presented major vascular injuries attributed to XLIF/MI XLIF. Two involved the L4-L5 level. The three complications included: one fatal injury, one, a retroperitoneal hematoma with hemorrhagic shock, and one major vascular injury. For the 5 review articles, major vascular complications were just discussed in 2, one study cited 3 specific major vascular injuries (e.g. 1 fatal, 1 life threatening, and 1 lumbar artery pseudoaneurysm requiring embolization), while 2 other studies stated the frequency of these injuries was 0.4% for XLIF, and 1.7% for OLIF (Oblique Lumbar Interbody Fusion).

**Conclusions:** According to 5 small and larger case series, 3 case reports, and 5 review articles, the incidence of major vascular injuries occurring during XLIF/MI XLIF ranges from 0 to 0.03% to 0.4%.

**Key words:** Extreme Lateral, Interbody, Fusion, Vascular Injuries, XLIF

**INTRODUCTION**

Extreme lateral interbody fusions (XLIF) and minimally invasive (MI) XLIF theoretically offer wide access to the lumbar disc space with the advantages of minimally disturbing surrounding structures (e.g. neural, vascular, soft-tissue), and providing stability. However, in addition to the already known high incidence of neurological deficits attributed to XLIF/MI XLIF procedures, here we analyzed the various frequencies of attendant major vascular injuries. Thirteen XLIF/MI XLIF studies were broken down into three categories; small/large series (5 studies; total of 6,732 patients), case reports (3 studies), and review articles (5 studies) The overall incidence of major vascular injuries occurring with XLIF/MI XLIF ranged from 0% to 0.03% to 0.4% [Tables 1-3].
Major Vascular Complications in Small/Larger Case Series of XLIF/MI XLIF

The incidence of major vascular injuries occurring for transposas XLIF/MI XLIF performed in the 5 small and larger case series involving a total of 6,732 patients (range from 12 to 4,607 patient/series) ranged from 0% (3 studies) to 0.03% (1 study) to 0.4% (1 study) [Table 1].[2,4,6,12,13] Karikari et al. (2011), evaluated 22 MI Thoracic/Thoracolumbar XLIF involving 47 levels; the 3 adverse events did not include any vascular injuries [Table 1].[8] Utilizing micro endoscopy in 96 patients undergoing 1-3 level MI XLIF for lumbar stenosis/scoliosis, Segawa et al. (2017), the overall complication rate was 18%, and included a 0.03% incidence of major vascular injuries.[7] Amongst Paterakis et al. (2018) study involving 12 XLIF, complications included no major vascular injuries.[10] When Walker et al., (2019) compared the incidence of major vascular complications occurring out of 1874 MI XLIF performed utilizing a transposas technique, the incidence of major vascular injuries was respectively 1.8% vs. 0.4%.[13]
### Table 2: Case Reports of Vascular Complications of XLIF 2014-2016.

| Author Journal Year | # Patients Series | XLIF Data | XLIF Data | Outcomes Vascular AE |
|---------------------|------------------|-----------|-----------|----------------------|
| Assina J Neurosurg Spine 2014 | Case: 1st Major Fatal Vascular Injury Due to XLIF | Pros of MI XLIF Wide Access Lumbar Disc Space | Minimal Tissue Disruption | 50-year-old-F Fatal Intraop Injury during L45 XLIF |
| Peiro-Garcia Rev Esp. Cir Ortop Traumatol 2016 | Case Report and Review; Retropertioneal Hematoma with XLIF | Segmental Arteries and Great Vessels Can be Damaged | Few Cases Life-Threatening Retropertioneal Hematoma | This is the First Stand-Alone XLIF and First Case Hemorrhagic Shock |
| Bucic Eur Spine J 2016 | Case: Direct Lesion and Repair Common Iliac Vein during L4-L5 XLIF | 69-year old F; DS-XLIF Risk of Major Vascular Injury | Problem: High Vena Cava Bifurcation Inadequate Preop Studies | Increased risk for XLIF at L4-L5 Level |

OLIF=Oblique Lateral Interbody Fusion, XLIF=Extreme Lateral Interbody Fusion, JSSR= Japanese Society Spine Surgery and Related Research, SS=Surgical Site Infection, DS=Degenerative Spondylolisthesis, Preop=Preoperative, REC=Recommendation, MIS=Minimally Invasive, F=Female, M=Male, SNI=Surgical Neurology International, BMC=BMC Musculoskeletal Disorder, VTAS=Visual Analog Scale, EBL=Estimated Blood Loss, OR=Operating Room, LOS=Length of Stay, Dscol=Degenerative Scoliosis, Oswestry=Oswestry Disability Index, AE=Adverse Event, Pts=Patients, Weak=Wk, Deg.=Degenerative, JOA=Japanese Orthopedic Association, and ODI=Oswestry Disability Index, ALIF=Anterior Lumbar Interbody Fusion, TLIF=Transforaminal Lumbar Interbody Fusion, PLF=Posterolateral Fusion, PLIF=Posterior Lumbar Interbody Fusion, OLIF=Oblique Lateral Interbody Fusion, PLF=Posterolateral Fusion, ASD=Adjacent Segment Disease, MI=Minimally Invasive

### Case Reports of XLIF/MI XLIF Involving Major Vascular Complications

There were 3 case reports of major vascular injuries occurring during XLIF/MI XLIF: two occurred during L4-L5 level procedures [Table 2].[1,3,11] The three complications reported in these three studies included; 1 fatal vascular injury, 1 life-threatening retropertioneal hematoma with hemorrhagic shock, and 1 major vascular injury [Table 2].[1,3,11] In 2014, Assina et al. described a major vascular injury occurring in a 50-year-old female undergoing a L4-L5 XLIF; the intraoperative vascular injury was fatal.[1] In 2016, Peiro-Garcia et al. presented a patient undergoing a stand-alone XLIF resulting in a life-threatening retropertioneal hematoma; they also emphasized how acute changes in vital signs should alert spinal surgeons of a likely major vascular injury (e.g. acute tachycardia, hypotension, and anemia).[11] In 2016, Buric et al. reported a 69-year-old female who sustained a common iliac vein laceration while undergoing a L4-L5 XLIF; they emphasized the need for safer preoperative planning to predetermine the location of the vena cava bifurcation.[1]

### Review Articles on XLIF/MI XLIF Involving Major Vascular Complications

Five review articles reviewed the frequency of major vascular complications occurring during XLIF/MI XLIF [Table 3].[2,4-6,8] Berjano et al. (2015) emphasized the need for better preoperative planning to identify the locations of major vessels and optimally plan docking points for XLIF to avoid major vessel injuries.[2] In 2016, Epstein's two articles cited the increased frequency of major neurological deficits and non neurological injuries, including vascular injuries, occurring with XLIF.[4,5] The latter article identified 3 major vascular injuries; 1 fatal injury, 1 life-threatening retropertoneal clot, and 1 iatrogenic lumbar pseudoaneurysm.[5] In 2019, Epstein further reported a collective 0.4% incidence of major vascular injuries attributed to XLIF/MI XLIF.[6] Of interest, in 2019, Li et al. cited a 1.7% incidence of vascular injury for OLIF (Oblique Lumbar Interbody Fusion), and a 0% incidence for LLIF (Lateral Lumbar Interbody Fusion).[19]

### DISCUSSION

Previous studies recognized the high incidence of neurological complications associated with XLIF/MI XLIF procedures [Tables 1-3]. These predominantly included injuries to the; lumbar plexus (13.28%), psoas weakness (4.3%-5.7%-31%), anterior thigh pain (12%-25%), sensory deficits (0-8.7%-40%-75%; 62.5% permanent), sympathectomy (4%-13.8%), and others [Table 1].[2,4,6,7,10,13] Here, we focused on the frequency of major vascular injuries attributed to XLIF/MI XLIF [Tables 1-3].[1-13] For the small and large series of patients undergoing XLIF/MI XLIF, 3 studies (e.g. involving 12, 22, 96 patients) found no vascular injuries, while 2 studies (e.g. involving 1995 and 4607 patients) respectively cited 0.03% and 0.4% frequencies of major vascular injuries [Table 1].[7,8,10,12,13] Three case studies...
reported one fatal intraoperative major vascular injury occurring during an XLIF; one life-threatening retroperitoneal hematoma, and one inferior vena cava laceration.\textsuperscript{[3,11]} Out of 5 review articles, one reported a 0.4% risk of a major vascular injury for XLIF/MI XLIF.\textsuperscript{[2,4-6,9]} Interestingly, the 5th of these 5 articles cited a 1.7% frequency of major vascular injuries for OLIF (Oblique Lateral Interbody Fusion) vs. 0% for LLIF (Lateral Lumbar Interbody Fusion).\textsuperscript{[2,4-6,9]}

### Critical Need for Preoperative Studies to Document Location of Major Vessels

Obtaining preoperative diagnostic studies to visualize the location of the major vessels was crucial for XLIF/MI XLIF operative planning e.g. for choosing the best and safest docking point(s) for the XLIF/MI XLIF devices.\textsuperscript{[5]} In particular, these studies should identify whether there is a high bifurcation of the inferior vena cava to limit the risk of inadvertent inferior vena cava (IVC) lacerations.\textsuperscript{[3]}

### Need for Intraoperative Recognition of Major Vascular Injury for XLIF/MI XLIF

It is imperative to immediately recognize an intraoperative major vascular injury while performing XLIF/MI XLIF. This allows for the immediate initiation of acute resuscitative measures. This includes recognizing a misplaced anterior

| Author Journal Year\textsuperscript{[REF]} | # Patients Series | XLIF Data | XLIF Data | XLIF Data | Outcomes Vascular AE |
|---------------------------------------------|-------------------|-----------|-----------|-----------|----------------------|
| Berjano Acta Neurochir (Wien) 2015\textsuperscript{[2]} | XLIF: Alternative to ALIF- Avoids Large Anterior Vessels; Must Know Anatomical Landmarks | Correct Lateral Positioning Reposition Every Level | Meticulous Study all-level Vascular and Neural Structures Concavity Side of Approach | Careful End Plate and Contralateral Preparation Preop Steroids Limits Postop Neural Deficits Especially at L4 | Avoid Over Distraction- Cage Subsidence AE: High Incidence Psoas Weakness, Hip/Groin/Thigh Pain/Dysesthesias |
| Epstein SNI 2016\textsuperscript{[4]} | XLIF; Pros and Cons vs. ALIF, TLIF, PLIF and PLF | Major Neuro Deficits: 13.28% Plexus Anterior Thigh Pain 25% Sensory 40% (Up to 75%) | XLIF Increased morbidity | Other AE: Sympathectomy Bowel Perforation Seromas |
| Epstein SNI 2016\textsuperscript{[5]} | Non Neuro Major AE: XLIF vs. ALIF XLIF Deficits Sympathectomy 4% Vs. 15% for ALIF | 3 Bowel Perforations 1 Seroma 1 L3-L4 Lateral Extraduction | Other AE: 45% Cage Overhang (XLIF Must Be Placed Anterior 1/3 of the Body) | Conclusion: “…many US-based spine surgeons fail to publish such adverse events …” |
| Epstein SNI 2019\textsuperscript{[6]} | XLIF/ MI XLIF Significant AE 13.28% Lumbar Plexus Injuries Up to 40% Sensory deficits (Permanent 62.5%) | AE: 40% Motor; 31% Iliopsoas 34% Anterior Thigh Pain 12% Sympathectomy; 13.8% Subsidence | Non Neurologic Deficits: 45% Cage Overhang 7.5% Pseudarthrosis | Other Failures Inadequate Decompression Bowel Injuries 0.4% Major Vascular Injuries |
| Li BMC 2019\textsuperscript{[9]} | Compared Outcomes LLIF vs. OLIF Reviewed 56 Studies | Both Similar: EBL, OR Time, LOS, Fusion Rate (over 90%) | Complications OLIF 26.7% LLIF 27.8% | 21.2% LLIF Higher Nerve Injury and Psoas Weakness | OLIF Higher 5.1% cage subsidence 5.2% Endplate Damage 1.7% Vascular Injury with OLIF |

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screw on intraoperative films, excessive bleeding from screw holes (with/without removal of the screw), and/or seeing acute changes in vital signs (acute anemia, tachycardia, cardiovascular collapse, and cardiac arrest). Singly or together, these findings may indicate that a major vascular injury has occurred during the XLIF/MI XLIF procedures.

CONCLUSION

An analysis of 5 small and larger case series, 3 case reports, and 5 review articles, revealed the incidence of major vascular injuries occurring during XLIF/MI XLIF ranges from 0 to 0.03% to 0.4%. When choosing to perform XLIF/MI XLIF, preoperative documentation of the location of the major vessels, and intraoperative acknowledgement of the signs of a major vascular injury are critical to operative success.

Declaration of patient consent

Patient's consent not required as there are no patients in this study.

Financial support and sponsorship

Nil.

Conflicts of interest

There are no conflicts of interest.

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How to cite this article: Epstein NE. Incidence of Major Vascular Injuries with Extreme Lateral Interbody Fusion (XLIF). Surg Neurol Int 2020;11:70.