



Review Article

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].

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Table 1: Small and Large Case Series of Vascular Complications of XLIF 2011-2019.

Author Journal Year ^[REF]	# Patients Series	XLIF Data	XLIF Data	XLIF Data	Outcomes Vascular AE
Karikari J Spine Disord Tech 2011 ^[8]	MI XLIF for Thoracic/Thoracolumbar Disease 22 Patients Average age 64.6 Years 2005-2009	D Scoli 11 Fracture 2 ASD/Prior Fusion 5 Thoracic Disc 3 Osteomyelitis 1	47 Levels EBL average 227.5 mL LOS 4.8 days Followed 16.4 mos.	3 AE:1 SSI, 1 Subsidence 1 ASD-Required More Surgery No Deaths	No Visceral Injuries No Vascular Injuries
Fujibayashi Spine 2017 ^[7]	2998 Cases; 2-Year Study XLIF 2013 -2015 71 Centers-2998 Cases 1995 XLIF 1003 OLIF	JSSR Questionnaires XLIF or OLIF Diagnosed Complications Salvage Surgery Outcomes	Analyzed 474 Complications (540 Occurred) Overall rate 18% 5.1% Sensory Nerve Injury	4.3% Psoas Weakness 0.7% SSI 0.03%Bowel Injury	Major Vascular Injury 0.03% Overall 2.2%
Segawa J Spine Surg 2017 ^[12]	XLIF Lumbar Stenosis and Scoliosis Microendoscopy to Prevent Injuries To: Lumbar Plexus, Segmental Arteries, Intestinal Tract	96 patients Pout comes JOA and ODI Scores 84-1 Level XLIF 9-2 Level XLIF 3-3 Level XLIF Average 1.2 Level XLIF	Average Age 61: Followed Average 18 mos. Avg. Preop/Postop JOA 11.9-15.6	ODI preop 38.6 Postop 19.1 3 (3.1%) AE: 2 End Plate Fractures 1 Deep SSI	No Vascular Injuries or Bowel Injuries
Paterakis Spine Surg 2018 ^[10]	12 XLIF DScoli Safety/Efficacy Outcomes VAS, Oswestry Scores XLIF 2008-2017 Average Age 64.5 Followed 28 mos.	XLIF Decreased Pain by 4.66 cm ODI Improved 26%	<u>Scoliosis Improved</u> 11.5 Degrees <u>Lordosis Changed</u> 13.5 Degrees	AE:3 Total 2 Meralgia Paresthetica 1 Bowel Perforation	3 of 12 AE with XLIF No Major Vascular Injuries
Walker J Neurosurg Spine 2019 ^[13]	AE MI XLIF Compared Prepsaos vs. Transpsaos Approaches Prepsaos: 1874 Patients Meta-analysis 20 Studies of AE and 8 for Pseudarthrosis	<u>Prepsaos Deficit</u> Sensory 21.7% Hip Wk. 19.7% Permanent Neuro Deficit 2.8%; Infection 1.1%;Subsidence 12.2%; Pseudarthrosis 9.9%	<u>Transpsaos Deficit</u> 4607 Patients Meta-analysis: 39 Studies AE and 19 for Pseudarthrosis <u>Deficits:</u> Sensory 8.7% Hip Wk. 5.7%	<u>Transpsaos Deficit</u> Permanent Neuro Deficit 1% Infection 3.1% Subsidence 13.8% Pseudarthrosis 7.5%	Prepsaos; Major Vascular Injury 1.8% Transpsaos Major Vascular Injury 0.4%

OLIF=Oblique Lateral Interbody Fusion, XLIF=Extreme Lateral Interbody Fusion, JSSR= Japanese Society Spine Surgery and Related Research, SSI=Surgical Site Infection, DS=Degenerative Spondylolisthesis, Preop;=Preoperative, REC=Recommendation, MIS=Minimally Invasive, F=Female, M=Male, SNI=Surgical Neurology International, BMC=BMC Musculoskeletal Disord, VAS=Visual Analog Scale, EBL=Estimated Blood Loss, OR=Operating Room, LOS=Length of Stay, DScoli=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, PLIF=Posterior Lumbar Interbody Fusion, PLF=Posterolateral Fusion, ASD=Adjacent Segment Disease, MI=Minimally Invasive

Major Vascular Complications in Small/Larger Case Series of XLIF/MI XLIF

The incidence of major vascular injuries occurring for transpsaos 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].^[7,8,10,12,13] 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) found no injuries to the segmental arteries.^[12] Of the 1995 XLIF studied over 2 years by Fujibayashi *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 prepsaos vs. 4607 XLIF using a transpsaos 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 ^[REF]	# Patients Series	XLIF Data	XLIF Data	XLIF Data	Outcomes Vascular AE
Assina J Neurosurg Spine 2014 ^[1]	Case: 1 st 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	Increased risk for XLIF at L4-L5 Level
Peiro-Garcia Rev Esp. Cir Ortop Traumatol 2016 ^[11]	Case Report and Review; Retroperitoneal Hematoma with XLIF	Segmental Arteries and Great Vessels Can be Damaged	Few Cases Life-Threatening Retroperitoneal Hematoma	This is the First Stand-Alone XLIF and First Case Hemorrhagic Shock	Tachycardia, Hypotension, anemia Most Prevalent signs Retroperitoneal Hematoma
Buric Eur Spine J 2016 ^[3]	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	Repaired Immediately	REC: Preop Plan with Study Vascular Structures Mandatory

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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 retroperitoneal 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 retroperitoneal 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.^[3]

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].^[2,4-6,9] 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 retroperitoneal 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).^[9]

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 1-3].^[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

Table 3: Review Articles of Vascular Complications of XLIF 2015-2019.

Author Year ^[REF]	Journal	# Patients Series	XLIF Data	XLIF Data	XLIF Data	Outcomes Vascular AE
Berjano Acta Neurochir (Wien) 2015^[2]		XLIF Alternative to ALIF- Avoids Large Anterior Vessels; Must Know Anatomic Landmarks	Correct Lateral Positioning Reposition Every Level Preop Plan Psoas Docking Point	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 L45	Avoid Over Distraction- Cage Subsidence AE: High Incidence Psoas Weakness , Hip/Groin/Thigh Pain/Dysesthesias
Epstein SNI 2016^[4]		XLIF; Pros and Cons vs. ALIF, TLIF, PLIF and PLF	<u>Major Neuro Deficits:</u> 13.28% Plexus Anterior Thigh Pain 25% Sensory 40% (Up to 75%)	XLIF Increased morbidity	Other AE: Sympathectomy Bowel Perforation Seromas	Other AE: Major Vascular Injuries
Epstein SNI 2016^[5]		<u>Non Neuro Major AE: XLIF vs. ALIF XLIF Deficits</u> Sympathectomy 4% Vs. 15% for ALIF	<u>Other AE XLIF</u> 3 Bowel Perforations 1 Seroma 1 L3-L4 Lateral Extrusion	<u>Other AE</u> 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 ...”	3 Major Vascular Injuries XLIF: 1 Fatal, 1 Clot-Retroperitoneal, 1 Iatrogenic Lumbar Pseudoaneurysm (Embolized)
Epstein SNI 2019^[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% Sympath- ectomy; 13.8% Subsidence	Non Neurologic Deficits: 45% Cage Overhang 7.5% Pseudarthrosis	<u>Other Failures</u> Inadequate Decompression Bowel Injuries 0.4% Major Vascular Injuries	1 Study -20 Papers 1080 XLIF Patients “Most (XLIF) studies are limited by study design, sample size, and potential conflicts of interest.”
Li BMC 2019^[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%	<u>21.2% LLIF Higher</u> Nerve Injury and Psoas Weakness	<u>OLIF Higher</u> 5.1% cage subsidence 5.2% Endplate Damage 1.7% Vascular Injury with OLIF

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reported one fatal intraoperative major vascular injury occurring during an XLIF, one life-threatening retroperitoneal hematoma, and one inferior vena cava laceration.^[1,3,11] Out of 5 review articles, one reported a 0.4% risk of a major vascular injury for XLIF/MI XLIF.^[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).^[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 critical to XLIF/MI XLIF

operative planning e.g. for choosing the best and safest docking point(s) for the XLIF/MI XLIF devices.^[2,3] 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.^[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

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.

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Conflicts of interest

There are no conflicts of interest.

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