Complication avoidance and management in anterior lumbar interbody fusion

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The goal of this study was to review the literature to compare strategies for avoiding and treating complications from anterior lumbar interbody fusion (ALIF), and thus provide a comprehensive aid for spine surgeons. A thorough review of databases from the US National Library of Medicine and the National Institutes of Health was conducted. The complications of ALIF addressed in this paper include pseudarthrosis and subsidence, vascular injury, retrograde ejaculation, ileus, and lymphocele (chyloretroperitoneum). Strategies identified for improving fusion rates included the use of frozen rather than freeze-dried allograft, cage instrumentation, and bone morphogenetic protein. Lower cage heights appear to reduce the risk of subsidence. The most common vascular injury is venous laceration, which occurs less frequently when using nonthreaded interbody grafts such as iliac crest autograft or femoral ring allograft. Left iliac artery thrombosis is the most common arterial injury, and its occurrence can be minimized by intermittent release of retraction intraoperatively. The risk of retrograde ejaculation is significantly higher with laparoscopic approaches, and thus should be avoided in male patients. Despite precautionary measures, complications from ALIF may occur, but treatment options do exist. Bowel obstruction can be treated conservatively with neostigmine or with decompression. In cases of postoperative lymphocele, resolution can be attained by creating a peritoneal window. By recognizing ways to minimize complications, the spine surgeon can safely use ALIF procedures.

(DOI: 10.3171/2011.7.FOCUS11141)

KEY WORDS
• anterior lumbar interbody fusion • anterior spine • complication • lumbar spine

Anterior lumbar interbody fusion is a valuable technique in the field of spine surgery. The advantages of ALIF are numerous. By accessing the lumbar spine via an abdominal incision, there is greater exposure of the anterior column, less muscular retraction with less blood loss, and reduced operative time. Access to the complete disc space allows greater distraction, and thus the ability to correct deformity as well as the ability to place larger interbody devices, increasing the likelihood of arthrodesis. Anterior lumbar interbody fusion is superior to transfemoral lumbar interbody fusion in its capacity to restore foraminal height, local disc angle, and lordosis, potentially improving sagittal balance and leading to better long-term outcomes. Manipulation and subsequent scarring of nervous structures are avoided, and in certain situations the canal and neural foramina can be indirectly decompressed. In addition, other stabilizing elements such as the dorsal bone, soft tissue, and associated tension bands are kept intact.

Despite these advantages, there are unique disadvantages to the procedure. A study of 447 patients by McDonnell et al.21 found that 11% of patients experienced major complications and 24% experienced minor complications after anterior surgical approaches to the spine. This set of complications is atypical in the realm of more standard neurosurgical procedures, and include injuries to abdominal viscera, the abdominal wall, great vessels, ureter, and numerous nerve plexuses.

The goal of our study was not to review the literature for the incidence of complications from ALIF, but rather to evaluate strategies for avoiding and treating those complications. By doing so, we hope to provide a framework for the safe use of ALIF.

Methods

Records from databases of the US National Library of Medicine and the National Institutes of Health (www.pubmed.gov) were queried to identify all studies pertaining to ALIF. The terms “anterior lumbar interbody fusion” and “ALIF” were used as search key words, and

Abbreviations used in this paper: ALIF = anterior lumbar interbody fusion; BMP = bone morphogenetic protein.
all English-language articles were perused for mention of complication rates and management strategies. Reference lists of all relevant articles were examined to identify additional studies.

**Results**

**Pseudarthrosis**

Pseudarthrosis, or nonunion, is a complication of any fusion technique, whether it be an anterior or posterior method. In a systematic review by Jacobs et al., the authors found a fusion rate ranging between 47% and 90% for ALIF, with most cited fusion rates approaching 90%. Several studies have identified factors that may decrease the incidence of pseudarthrosis, including graft/cage preparation and usage, the use of biologics, and the addition of supplemental instrumentation.

Thalgott et al. performed a study in which 50 patients undergoing ALIF were randomized to receive either frozen or freeze-dried femoral ring allograft. Six of 7 patients who experienced pseudarthrosis received the freeze-dried allograft, suggesting a benefit for frozen allograft products as opposed to freeze dried, although a mechanism for this difference was not proposed. Madan et al. compared 27 patients who received noninstrumented ALIF (that is, graft only) with 29 patients who received instrumented ALIF (that is, graft and cage). The authors found a significant difference in fusion rates between the 2 groups of 83.3% and 100%, respectively, arguing for the use of instrumentation in ALIF procedures.

The use of biologics in spine surgery has become prevalent, particularly with the advent of BMPs. In 2004, Burkus reported on a prospective, multicenter, randomized study in which 22 patients undergoing ALIF received autograft, whereas 24 patients received a recombinant human BMP-2–coated absorbable collagen sponge carrier and allograft bone dowels. The 2-year radiographic fusion rates were 68.4% and 100%, respectively. This study was repeated with nearly 3 times the number of patients and produced similar results (2-year fusion rates of 81.5% and 100%, respectively). However, Pradhan et al. found that the use of BMP with femoral ring allograft produced the opposite result, with pseudarthrosis occurring in 36% of patients with iliac crest bone graft/femoral ring allograft and in 56% of patients with femoral ring allograft and BMP-2. This difference was attributed to aggressive BMP-induced resorption. Thus, BMP can augment bone fusion, but only in the proper environment.

Lastly, whereas a number of studies have shown greater fusion rates in ALIF when supplemented posteriorly, the guidelines set forth in 2005 by Resnick et al. do not advocate a circumferential fusion in the setting of 1- or 2-level disc disease, citing much higher rates of complications when an additional posterior approach is used.

**Subsidence**

Subsidence is “a decrease in the vertical height of the disc space prior to complete incorporation of the fusion mass.” The goal in any interbody fusion procedure is to restore disc height and neural foramina caliber; the occurrence of subsidence is therefore counterproductive. Beutler and Peppelman identified increased reaming depth and larger cage sizes as risk factors for subsidence. In terms of the latter, the average cage sizes for patients who did and did not develop subsidence were 16.1 mm and 14.7 mm, respectively. In osteoporotic patients, Kim et al. found that augmenting the ALIF with vertebral body injections of polymethylmethacrylate (a vertebroplasty) resulted in a significantly decreased degree of cage subsidence. It should be noted, however, that these patients underwent supplemental pedicle screw fusions posteriorly.

**Vascular Complications**

The abdomen contains anatomy unfamiliar to most neurosurgeons, and many vascular structures are exposed and at risk for injury during ALIF. These structures include the great vessels, segmental vessels, and numerous veins. Anatomically, the abdominal aorta bifurcation is usually found at the level of the L-4 vertebral body, while the confluence of the inferior vena cava is usually located at the level of the L-5 vertebral body.

Vascular injury during ALIF was thoroughly reviewed by Inamasu and Guiot. These authors found that vascular injury most often occurred when operating at the L-4–5 level, given the aforementioned anatomy. Venous laceration was the most common vascular injury and usually occurred during retraction of the great vessels. Other mechanisms of injury included performing the discectomy, placing the graft, and removing the temporary pin. The veins most commonly lacerated were the left common iliac vein, inferior vena cava, and iliolumbar vein. Manual compression and/or primary suture were generally effective at treating this complication. Sasso et al. found that venous injury was significantly more common when using threaded fusion devices (such as machined bone dowels and cylindrical titanium implants) compared with nonthreaded ones (such as iliac crest autograft and femoral ring allograft). This finding was attributed to the added instrumentation needed to place threaded devices.

In their review, Inamasu and Guiot found that the most common arterial injury occurring during ALIF is left iliac artery thrombosis. This complication occurs due to prolonged retraction of the common iliac arteries to the right, causing diminished arterial flow and subsequent left-sided thrombosis. Treatment of this complication is considered an emergency and involves thrombectomy and/or bypass surgery. Preventative strategies proposed include intermittent release of the retraction intraoperatively, and lower-extremity pulse oximetry during and after the procedure. Injury to the bilateral inferior epigastric arteries has also been reported.

In a retrospective review of prospectively collected data on 212 patients who underwent ALIF, Garg et al. found a significantly increased risk of vascular injury when 2 spinal levels were instrumented, and in male patients. The authors advocated preoperative evaluation and intraoperative exposure by a vascular surgeon. At our institution, exposure is provided by our colleagues in general surgery.

**Postoperative Adynamic Ileus Versus Acute Colonic Pseudoobstruction**

Adynamic postoperative ileus is a major detei-
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nant of length of stay following abdominal operations. Postoperative ileus occurs most commonly in patients undergoing major bowel operations, and is recognized as a common reason for delayed hospital discharge following these operations. Postoperative ileus is also frequently observed in extraperitoneal abdominal operations, including ALIF, and portends an increased risk of hospital readmission and increased health care costs overall. In addition, postoperative ileus stands as a barrier to effective pain management in many of these patients. Three general pathogenic mechanisms of postoperative ileus are typically cited—neurogenic, inflammatory, and pharmacological. Human and animal experimental evidence suggests that reactive hyperactivity of the sympathetic nervous system overcomes normal parasympathetic-driven gastrointestinal smooth-muscle activity, diminishing normal gastrointestinal motility. Detailed explanation of the mechanisms by which postoperative ileus occurs is beyond the scope of this article; however, the effects of postoperative ileus following ALIF can potentially be diminished by optimizing postoperative medication regimens and nutrition, as well as using nonnarcotic pain control strategies.

A diagnostic quandary occasionally arises after ALIF in differentiating postoperative ileus from Ogilvie syndrome. Acute colonic pseudoobstruction, as Ogilvie syndrome is now known, was described by William Ogilvie in 2 patients with intraabdominal malignancy. Whereas the vagus nerve carries parasympathetic innervation to the esophagus, stomach, small intestines, and proximal colon, the sacral plexus provides parasympathetic innervation to the distal colon. Ogilvie hypothesized that these masses impinged upon his patients’ sacral plexuses, resulting in disruption of normal parasympathetic innervation. Though the exact mechanism of acute colonic pseudoobstruction remains uncertain, the preponderance of cases involving retroperitoneal pathologies or spinal anesthesia suggests that pathology at the level of the sacral plexus is involved. The high efficacy of parasympathomimetic agents in the treatment of acute colonic pseudoobstruction suggests that dysregulation of colonic autonomic function is involved. Although uncommon, acute colonic pseudoobstruction can result in cecal perforation in as many as 20% of cases, which has an associated mortality rate of 25%–60%.

Acute colonic pseudoobstruction has been diagnosed as a postoperative condition in 50%–60% of cases, and as a common medical condition (including metabolic and oncological). Mechanical disruption of parasympathetic innervation to the colon is typically believed to cause acute colonic pseudoobstruction, and both the intraperitoneal and retroperitoneal approaches in ALIF pose this risk. This is believed to occur both by direct manipulation of these nerves and by retroperitoneal hematoma. In addition, the risk of ischemic insult to the sacral plexus has also been hypothesized to contribute to acute colonic pseudoobstruction, given the relatively high incidence rate noted in vasculopathic patients. In 1 series, 22% of postoperative acute colonic pseudoobstruction cases were observed following spinal cases and 25% after coronary artery bypass grafting. Acute colonic pseudoobstruction has been reported to occur following posterior spinal operations as well as in ALIF.

Colonic distension can be caused by a number of mechanisms including metabolic, mechanical, septic, and pharmacological. Postoperative ileus, toxic megacolon, and mechanical obstruction must be considered as well when diagnosing acute colonic pseudoobstruction. Symptoms typical of a proximal large bowel obstruction, including abdominal pain, distension, nausea, vomiting, constipation, or diarrhea, might suggest the need for further investigation. Colonic dilation is typically observed from the cecum to the splenic flexure on plain abdominal radiographs, and CT or contrasted enema should rule out mechanical obstruction. Laboratory evaluation often reveals leukocytosis or metabolic derangement. Aggressive correction of metabolic abnormalities, nasogastric suction, bowel rest, and regularly scheduled enemas should be included in the strategy for initial conservative management.

Intravenous neostigmine (using a standard dose of 2.0 mg) is typically the second-line intervention and, among prospective series, has shown a long-term efficacy rate of 64%–100%. Administration of neostigmine should be performed with the patient supine, with continuous cardiopulmonary monitoring and with atropine readily available. Side effects of neostigmine can be diminished by reducing dosage or by coadministration of glycopyrrolate.

The third-line intervention is colonoscopic decompression. Surgical interventions such as percutaneous colostomy and surgical necostomy are appropriate in symptomatic patients with extreme colonic dilation (often defined as 12–13 cm, but the utility of radiographic criteria for this condition is unsubstantiated), in whom other more conservative measures have failed.

Retrograde Ejaculation

Retrograde ejaculation can complicate any abdominal surgery in male patients due to injury of the superior hypogastric plexus, which lies beneath the peritoneum, courses anterior to the aorta, and crosses anterior to the left common iliac vein. The one consistent finding in the literature regarding retrograde ejaculation is its increased incidence with the use of laparoscopic approaches. Kaisar et al. found the rate of retrograde ejaculation to be 45% with laparoscopic approaches compared with 6% in cases using a mini-open approach. Similarly, Escobar et al. found rates of 25% and 2%, respectively. The association between laparoscopy and retrograde ejaculation is due to the transperitoneal nature of laparoscopy and the proximity of the superior hypogastric plexus to the peritoneum. The utilization of laparoscopic ALIF appears to be diminishing, given the feasibility of open and mini-open surgical approaches.

Lymphocele

Postoperative lymphocele, or chylolymphocele, is an uncommon complication following anterior spine surgery. Lymph vessels and nodes are numerous around the spinal column, and persistent leakage can result in lymphedema, mechanical compression, nutritional deficiencies,
immunosuppression, and death. There is no data available to suggest the best way to avoid lymphatic injury. Typical management options include observation and drainage. Schizas et al. reported good results in 1 case treated via laparoscopic marsupialization. At our institution, we treated chyloretroperitoneum via a peritoneal window, which was performed (by a general surgeon) by creating an opening in the posterior peritoneal wall to allow the lymph to drain into the peritoneal space. We have since used the peritoneal window to treat 2 additional patients with chyloretroperitoneum, without recurrence.

**Discussion**

Including ALIF as part of one’s surgical armamentarium provides a useful tool for treating a number of spinal pathologies. Anterior lumbar interbody fusion is a superior method of restoring foraminal height and focal lordosis, making it an important tool for correction of lumbar lordosis and deformity. However, it is important for spine surgeons to be aware of the complications that may result from the ALIF approach, as well as knowledge of how to avoid and treat the complications that inevitably will occur. Rather than evaluate articles that report the incidence and types of complications associated with ALIF, our goal was to compare strategies for avoiding and treating such adverse outcomes. In this respect, the literature available was much more limited. Based on these studies as well as our own practices, we present the following recommendations.

The use of interbody cages compared with allograft placement results in higher fusion rates. The combination of recombinant human BMP-2 with allograft appears superior to autograft and minimizes the likelihood of pseudarthrosis. Frozen femoral ring allograft appears to be a viable alternative interbody implant that will avoid the added instrumentation and manipulation required with cage placement, which frequently is associated with venous injury. If interbody cages are used, lower cage heights will decrease the risk of subsidence.

Whereas venous injury is the most common complication of ALIF, arterial injury is the most serious. Careful preoperative evaluation to assess for symptoms of vascular claudication in conjunction with a physical examination to palpate lower-extremity pulses should be performed in any patient for whom an ALIF is considered. Worrisome findings during this examination should prompt a referral to the vascular surgery department. Intraoperatively, arterial injury can be avoided by using lower-extremity pulse oximetry and intermittently releasing retraction of the great vessels. Venous injury (laceration) can be avoided by careful manipulation of the retractors. Manual compression and/or primary suture should be used when laceration occurs.

Postoperative ileus following ALIF can be minimized with bowel rest until signs of gastrointestinal motility are manifested (such as bowel sounds and passing gas) and by avoiding constipating medications (such as narcotics). Acute colonic pseudo-obstruction (Ogilvie syndrome) can usually be treated conservatively, although neostigmine or decompression is occasionally warranted.

Finally, the laparoscopic approach should be avoided in male patients, given the evidence for an increased rate of retrograde ejaculation. In addition, the use of electrocauterization should be minimized in the vicinity of the superior hypogastric plexus (dorsal to the peritoneum).

**Conclusions**

While the incidence of complications from ALIF can be relatively high compared with more common spinal surgical procedures, knowledge of these complications and the use of strategies to avoid them will allow the spine surgeon to use this technique safely.

**Disclosure**

Dr. Park serves as a consultant to DePuy Spine and Globus.

Author contributions to the study and manuscript preparation include the following. Conception and design: La Marca. Acquisition of data: Than, Wang, Rahman, Wilson. Analysis and interpretation of data: Wang, Wilson. Drafting the article: Than, Wilson. Critically revising the article: Park, Valdivia. Reviewed submitted version of manuscript: Park, Than, Valdivia. Approved the final version of the manuscript on behalf of all authors: Park. Study supervision: Park, Rahman, Valdivia, La Marca.

**Acknowledgment**

The authors would like to thank Holly Wagner for providing editorial assistance in the preparation of this manuscript.

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Manuscript submitted June 14, 2011. Accepted July 19, 2011.

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