Combined aorto-iliac and anterior lumbar spine reconstruction: A case series

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Introduction

The incidence of symptomatic degenerative disc disease (DDD) increases with age, with the lifetime prevalence being estimated at 60-90% [1-3] (see figure 1). Disc degeneration is the initial step in the cascade of degenerative spinal changes, followed by osteophyte development, disc narrowing, facet decoupling, arthritis and spinal stenosis [4]. The benefits of spinal reconstruction for patients with symptomatic DDD and radiculopathy is well established in the literature [5,6]. Anterior reconstructions, in particular, have been shown to reduce the risk of neurological complications [5]and morbidity [7] post operatively in comparison with other approaches. Patients with chronic low back pain (CLBP) due to DDD, who have failed to respond to conservative management, can benefit from surgical intervention; with both fusion and total disc replacement (TDR) being accepted treatment options [8]. Surgical intervention has been shown to have positive effects on both back and leg pain as well as self-rated quality of life [9-12].

The prevalence of both aortic-iliac occlusive disease (AIOD) and abdominal aortic aneurysm (AAA) also increases with age, with the incidence of AAA estimated at 4-7% of men and 1-2% of women over the age of 65 [13,14] (see figure 2). Modern surgical techniques allow for treatment of aortic disease with either open aortic surgery (OAS) or through endovascular aneurysm repair (EVAR) [15]. Lower mortality and morbidity rates are present for EVAR over OAS; however, late complications, higher re-intervention rates and decreased late survival[16] may offset this advantage [17]. While aortic and spinal conditions often present separately, with regard to patient symptoms, they can often co-exist. Further, arterial occlusion can significantly decrease the nutrition of the disc and lead to progressive disc disease [18]. Kurunlahti, Tervonen, Ilkko, Suramo, Vanharanta [19] revealed that this association between atheromatous lesions in the abdominal aorta and DDD is significantly higher in patients with low back pain.

A patient presenting with severe chronic back and leg pain may have a significant vascular pathology that weighs equally in consideration for surgical review and possible treatment (see figure 1). If considered to be at risk of rupture, there is clear consensus that the vascular pathology needs surgical repair [15,20]. The issue of how and when to treat vascular and spinal pathologies is complex and yet to be resolved. The treatment of the AIOD first and separately would preclude an anterior reconstruction and its associated benefits. A two-stage procedure means two anaesthetics for the patient, two surgical procedures, a longer overall stay in hospital, and a delay in resolution of their symptoms. Additionally, it doubles the preoperative stress response and postoperative pain as well as leading to higher costs of treatment[21].

Considering that operating rooms can consume up to and excess of 40% of a hospital's annual budget [22] optimization of resources and providing quality care is paramount. For example, bilateral total knee and hip arthroplasty where a patient has both joints replaced under a single anaesthetic is 36% and 25% less costly than two unilateral arthroplasties respectively [21]. Regarding the cost of open compared to endovascular repair of abdominal aortic aneurysms, the overall costs have been found to be higher with endovascular techniques [23]. Extrapolating, this combined strategy employing open vascular techniques has the potential to not only reduce overall healthcare costs from avoiding staged surgery but also avoiding the need to employ endovascular techniques and their associated higher rate of late complications.

A systematic search of the literature revealed no published reports of surgery to concurrently treat AIOD and DDD at a single operative event. While a case series is considered to be a low level of evidence, the absence of any literature provides rationale for this case series. Therefore, the purpose of this case series was to document the feasibility and safety of a combined reconstructive procedure performed for aortic and lumbar spine pathologies and the outcome of five patients who have undergone this procedure.

figure 1 here

figure 2 here

Patients and Methods

A prospective, uncontrolled clinical case series in a single institution was conducted. Between the period of September 2012 to March 2016, 2756 new cases presented at a specialist spinal clinic. A total of five cases (incidence proportion of 0.18%) presented to with dual pathologies of DDD with radiculopathy and AIOD, subsequently undergoing a combined surgical technique.

Two experienced surgical teams were involved and detailed preparation undertaken in advance of the procedure. In theatre, there was utilization of a radiolucent modular operating table, separate vascular and spinal nursing teams and surgical assistants, a neuromontitoring team, blood reperfusion processes backed by cross matched blood, experienced radiographers, as well as the management of the anesthetic by a vascular anesthetist.

Patient demographics, individual surgical information (including operative time, blood loss, transfusion requirements) and post-operative information (including length of stay and complications) has been reported in all cases and is presented within Table 1. Spine specific outcome

measures including Roland Morris Disability Questionnaire (RMDQ), Oswestry Disability Index (ODI) and Visual Analogue Score (VAS) for both back and leg pain were assessed pre-operatively and at 3, 6 and 12 months post operatively and can be found in Table 2.

Eligibility of patients for concurrent procedure:

Decision making regarding elective repair of both AAA and DDD requires careful assessment of multiple criteria. The indications for spinal surgery were 1 or 2 level degenerative disc disease and/or spondylolisthesis with associated radiculopathies. All patients presented with debilitating symptoms of at least 6 months' duration that had not improved with appropriate non-operative treatments. This criterion has previously been applied for hybrid procedures where both TDR and ALIF were utilised for the treatment of DDD[12].

The criteria applied to warrant AAA repair commonly involves an aneurysm of 5.5cm or greater [17]. While this threshold is based off the best available evidence it is not possible to apply a single threshold diameter which can be generalised to all patients and hence the need of an individualised approach which considers the factors of rupture risk, operative mortality and life expectancy[17].

With relevance to the current case study, all 5 cases are substantially younger (average age of 61.6 years) than the typical vascular patient[24] where maximum AAA incidence rates have been shown to be aged between 75-79 years[25]. Therefore, all cases had a significant potential for an extended life beyond presentation. Given the subset of younger patients and the higher life expectancy repair was warranted within the patients who presented with a AAA of less than 5.5cm in diameter.

The spinal procedures undertaken in these cases utilised open surgery with either a retroperitoneal or transperitoneal approach and consequently would involve displacement, distortion, compression and stretching of the aorta to allow access. Without prophylactic repair the AAA sac would limit access to the spine and, thus, the risk of rupture during spinal surgery necessitates addressing the vascular lesion at the time of spinal reconstruction. Therefore, without treatment of the vascular lesion the appropriate anterior spinal procedure would not have been possible.

The standard anticoagulation protocol followed in this case series was 50000 units of heparin was administrated before the cross clamping of the aorta. If the clamp time exceeded 90 minutes an additional 1000 units was given. No reversal agents are administered after closure, unless ooze or a leakage is detected. Post- operative physical and chemical prophylaxis consisted of ted stockings,

gentle physical therapy and 40 milligrams of clexane subcutaneously twice daily. This was continued for four weeks.

*** Table 1 here***

table 2 here

Case 1

A 61-year-old female presented for assessment of CLBP and bilateral sciatica with symptoms suggestive of both neurogenic and vascular claudication. Despite appropriate non-operative treatment, her symptoms had deteriorated to the extent that she required walking sticks to ambulate. She also reported a smoking history. Pre-operative outcome measures pertaining to Case 1 have been reported within Table 1.

Clinical examination revealed flattening of her lumbar lordosis and a restricted range of motion in the lumbar spine. Neurological examination of the lower limbs was normal. Pedal pulses were absent. Electromyography (EMG) examination confirmed bilateral L5 radiculopathies. Spinal imaging (MRI, CT and discogram) showed advanced DDD in the lower lumbar spine, with L3-4 auto fused, disc degeneration with an annular tear at L4-5, and disc degeneration with loss of disc height and bilateral neuroforaminal stenosis at L5-S1. Significant calcification throughout the aorta and iliac arteries was also noted. She was referred on for vascular assessment and a CT angiogram was performed. This showed severe AIOD with complete occlusion of the distal aorta and both iliac arteries. After consultation between spine and vascular services and shared decision making with the patient, it was decided to proceed with a combined lumbar hybrid procedure (L4-5 TDR and L5-S1 ALIF) and aorto bi-iliac bypass.

Surgery was performed through a standard midline laparotomy, using a transperitoneal approach. The spinal reconstruction was performed first. The L4-5 level was exposed and reconstructed with TDR, after ligation of the iliolumbar vein and mobilization of the aorta and vena cava to the right. The L5-S1 level was approached and reconstructed with ALIF between the iliac vessels, after ligation of the median sacral vessels. On completion of the spinal reconstruction, an aorto bi-iliac bypass was performed using a 14mm bifurcation graft. Total operative time and blood loss were respectively 8 hours 26 minutes and 2960ml (requiring 2 units of post-operative transfusion).

The patient was monitored in the ICU overnight and then transferred to the ward. After increasing her mobility on the ward, the patient was discharged home (total of 16 days inpatient stay). There were no postoperative complications and good perfusion was restored to both lower limbs. The 12 month follow-up of outcomes post-surgery for case 1 can be seen in Table 2, with improvements made in all outcome measures pertaining to the spinal surgery.

Case 2

A 60-year-old male presented for assessment of CLBP and right-sided sciatica that had failed conservative management. He had undergone a L5-S1 laminectomy 20 years earlier. Pre-operative outcome measures pertaining to Case 2 have been reported within Table 1.

A CT scan showed a degenerate disc with an extrusion compressing the right L5 nerve root at L4-5, an auto-fused L5-S1 level and a 6cm infra-renal AAA. Clinical examination revealed a Trendelenburg gait and weakness of ankle dorsiflexion on the right side. EMG examination showed bilateral L5 radiculopathies as well as a left L4 radiculopathy. The patient was referred for a vascular assessment and the AAA was deemed suitable for either open or endovascular repair. After consultation with spine and vascular services and shared decision making with the patient, it was decided to proceed with a combined open AAA repair and L4-5 TDR, with removal of the disc extrusion.

Surgery was performed through a standard midline laparotomy. The aorta was clamped just below the renal arteries, opened and the proximal end of the graft attached. This was folded out of the way and the aorta was then transected above the bifurcation with control of the iliac vessels. The L4-5 disc was then exposed. After discectomy and removal of the extruded fragment a TDR was inserted. The remnants of the aortic wall were placed back over the top of the TDR and then the distal anastomosis completed. Total operative time and blood loss were respectively 5 hours 30 minutes and 1375ml. No post-operative transfusion was required.

The patient had an uncomplicated post-operative course, was mobilized on the ward and discharged home (total of 12 days inpatient stay). The 12-month follow-up of outcomes post-surgery for case 2 can be seen in Table 2 with improvements made in all outcome measures pertaining to the spinal surgery and no post-operative complications were reported at any time point during data collection.

Case 3

A 66-year-old male presented for assessment of CLBP and bilateral sciatica that had failed conservative management. Pre-operative outcome measures pertaining to Case 3 have been reported within Table 1.

Examination revealed loss of lumbar lordosis and wasting in the buttocks bilaterally. He was tender over the lower lumbar spine and pedal pulses were reduced. EMG examination showed bilateral L5

and right S1 radiculopathies. Imaging studies showed advanced DDD at L4-5 and L5-S1, with neuroforaminal stenosis at both levels and a focal AAA was noted at L4-5.

The patient was referred for a vascular opinion, with CT angiogram confirming a 4cm AAA with an associated 23mm right common iliac aneurysm. After consultation with spine and vascular services and shared decision making with the patient, it was decided to proceed with a combined aorto-iliac bypass and L4-5 L5-S1 ALIF.

Surgery was performed through a standard midline laparotomy. At the time of surgery, the aortic disease had progressed almost up to the renal arteries and the left common iliac was seen to be elongated and tortuous. The aorta was clamped just below the renal arteries. A 20mm x 10mm bifurcated graft was then attached end to end proximally and end-to-end on the right. On the left the graft was also attached end to end but initially left long to allow the spinal reconstruction. The L5-S1 ALIF was then performed between the iliac vessels and then the L4-5 ALIF was performed, after mobilizing the vena cava and left common iliac vein to the right. At the end of the spinal procedure, the left iliac graft was shortened and reattached end-to-end. Total operative time and blood loss were respectively 5 hours 29 minutes and 1160ml. No post-operative transfusion was required.

The patient had an uncomplicated early post-operative course was mobilized on the ward and discharged home (total of 8 days inpatient stay). There was development of right sacroiliac joint pain at 12 months post-operatively, which responded well to an intra-articular steroid injection. The 12 month follow-up of outcomes post-surgery for Case 3 can be seen in Table 2 with improvements made in all outcome measures pertaining to the spinal surgery.

Case 4

A 48-year-old man presented for assessment of CLBP and bilateral leg pain that had failed conservative management. Pre-operative outcome measures pertaining to Case 4 have been reported within Table 1.

Examination revealed loss of lumbar lordosis, significant restriction in range of motion in the low back and mild weakness of ankle dorsiflexion bilaterally. An MRI of the lumbar spine prior to assessment by the spine service had shown an isthmic spondylolisthesis of L5 on S1, with a degenerative disc above at L4-5. The MRI also revealed a 7cm AAA, with an associated 3cm left common iliac aneurysm. EMG confirmed bilateral L5 radiculopathies. The patient had a vascular

review prior to spinal review and, given the size of the aneurysm, surgical repair was advised. After consultation with spine and vascular services and shared decision making with the patient, it was decided to proceed with a L4-5 TDR and L5-S1 ALIF at the same time as the aorto-iliac bypass.

The surgery was performed through a midline laparotomy. The aorta was clamped just below the renal arteries and the proximal end of a bifurcation graft attached end to end. The right iliac graft was then attached. The left sided repair was performed after the spinal reconstruction. The L5-S1 disc was exposed between the iliac vessels. The disc space was released and discectomy performed. Reduction of the spondylolisthesis was achieved and ALIF performed. The L4-5 disc was then exposed and discectomy performed followed by insertion of a TDR. At the end of the spinal reconstruction, occlusion of the right iliac graft limb was noted and required thrombectomy and revision of the anastomosis. The left iliac anastomosis was then completed and the abdomen closed. Total operative time and blood loss were respectively 7 hours 10 minutes and 2000ml (mostly due to flushing of the blood vessels and graft limbs). No transfusion was required post-operatively.

The patient was monitored in the ICU before transferring to the ward to mobilize. He had an uncomplicated early post-operative course and was discharged home (total of 10 days inpatient stay). At 12 months post-operatively the patient developed vascular claudication in both legs and a CT angiogram showed kinking of the iliac graft limbs due to extension/expansion of the aortic limb of the graft. The patient was taken to the catheterization laboratory where endovascular stenting of both iliac grafts was performed, consequently restoring normal blood flow to the lower limbs. The 12 month follow-up of outcomes post-surgery for Case 4 can be seen in Table 2, with improvements made in all outcome measures pertaining to the spinal surgery.

Case 5

A 73- year -old male presented with CLBP as well as left leg pain with associated weakness that had failed conservative management. Pre-operative outcome measures pertaining to Case 5 have been reported within Table 1.

Examination revealed loss of lumbar lordosis and a painful step at L5-S1. Weakness was present in dorsiflexion in both legs, with the left weaker than the right. Radiology revealed a grade 2 spondylolithesis of L5-S1. MRI and CT scan revealed significant neuroforaminal stenosis. EMG revealed bilateral L5 and S1 radiculopathies. The radiology also revealed a small AAA and a vascular opinion was arranged together with CT-Angiography. A saccular AAA measuring 40mm by 35 mm was noted together with extensive calcific atherosclerosis. The calcification, which is normally in the

media, remained in the major saccular enlargement, suggesting a thin layer of adventitia and thus raising the possibility of dissection and rupture. After consultation with spine and vascular services and shared decision making with the patient, it was decided to proceed with L5-S1 ALIF and an AAA repair.

A standard trans peritoneal approach was performed. An aorto-bi-femoral technique was decided upon with the proximal connection being performed first. The AAA was found to have a friable adventitia only of 3mm thickness. The vessels distally were prepared, which allowed exposure to L5-S1 for an ALIF. Following this, the femoral anastomosis was performed. Total operative time and blood loss were respectively 3 hours 50 minutes and 1800ml. There was no post-operative transfusion required.

The patient had an uncomplicated surgery and was then transferred to ICU for 2 days, then to the spinal ward (10 days) and rehabilitation ward (10 days) (total of 22 days inpatient stay). The 12 month follow-up of outcomes post-surgery for Case 5 can be seen in Table 2, with improvements made in all outcome measures pertaining to the spinal surgery and no post-operative complications were reported at any time point during data collection.

figure 3 here

Discussion

Given the overlap of risk factors for both aortic disease and DDD, it is not surprising to discover that patients present to primary care with both pathologies on a regular basis. In many cases, one or both conditions are managed with observation. There are occasions, however, in which surgical intervention is indicated for both conditions due to the risk of spontaneous bleeding, significant pain levels, neurological decline and effects on quality of life. Our experience is that successful use of this combined technique requires substantial pre-operative discussion and intra-operative co-ordination.

The aim of this case series was to document the feasibility and safety of a combined reconstructive procedure performed for aortic and lumbar spine pathologies. A systematic search of the literature revealed no published research whereby concurrent aortic and lumbar pathologies were treated in the same operation. Therefore, documenting this case series provides insight into the type of patients who can undergo such a procedure and the associated post-operative outcomes.

The results of this study revealed substantial improvements in all outcome measures (RMDQ, ODI, VAS) for both conditions that are maintained for a 12-month period post operatively with minimal complications. Regarding transfusion, Case 1 was the only patient that required a post-operative

transfusion (2 units) with the total intraoperative blood loss being between 1160 to 2960 milliliters. The mid- to long-term survival benefit to these patients from prophylactic treatment of the AIOD in this setting cannot be evaluated but would be expected to be favorable, consistent with historical studies[23].

Two out of the five cases (case 3 and 4) developed a complication 12 months' post operation; case 3 being right sacroiliac joint pain which was treated with an intra-articular steroid injection and case 4 developed bilateral vascular claudication and underwent an endovascular stenting of both iliac grafts. This case series revealed an average ICU stay to be 2.8 days and ward stay 8.8 days. The operative times varied from 220 to 506 minutes (average 365 minutes). These timeframes appear to be reasonable considering the patient was recovering from one combined procedure, which treated two significant pathologies.

Previous articles have highlighted the incidence of atypical back pain and subsequent vertebral lysis and pain due to a AAA [26] and the indication of AAA repair due to the proximity of a large osteophyte in the lumbar spine [27], however this is the first instance of a combined technique. In these studies, only the AAA was repaired with the large osteophyte not requiring treatment, and in the other the vertebral bodies were stabilized with pedicle screws, while the AAA was left due to healthy kidney arteries and distal flow from collaterals. While the left retroperitoneal approach is often preferred for AAA repair due to its ability to expose the entire infradiaphramatic aorta with access to the supra-renal aorta[28], the anterior approach was required for the spinal surgery in these instances. This approach was utilised to ensure the task was safely performed. This approach is commonly used for larger AAA repairs[28] and may allow a larger working space and natural orientation to anatomical landmarks[29].

For this particular combination of surgical procedures it is considered that a multidisciplinary approach is crucial in planning for success in surgical outcomes[30]. Consultation with a number of specialties and close study of pre-operative vascular imaging is required to address suitability, priority, the effect of co-morbidities and the development of a surgical plan. It is proposed that this type of approach has the potential to improve efficiency and outcomes while reducing adverse events and overall costs as well as leading to high levels of patient satisfaction [30]. Substantial improvements in all outcomes measures and acceptable complication levels confirm the feasibility and safety of this combined procedure.

Conclusion

While AIOD and DDD commonly co-exist, simultaneous treatment of vascular and lumbar spine pathologies is indicated in rare circumstances. This case series shows that, despite it being a complex treatment strategy, it is feasible and can produce significant benefits to both pathologies with minimal complications for patients. This procedure brings together unique clinical circumstances and highly trained individuals in a specialised setting to achieve a desirable outcome for the patient.

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Figure Legends:

Figure 1: Sagittal view of both DDD and AAA pathologies

Figure 2: CT scan of revealing AIOD and AAA

Figure 3: Surgical Reconstruction involving a TDR, ALIF and AAA open repair