Early outcomes of patients transferred with ruptured suprarenal aneurysm or dissection

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ABSTRACT

OBJECTIVE Despite centralisation of the provision of vascular care, not all areas in England and Wales are able to offer emergency treatment for patients with acute conditions affecting the aorta proximal to the renal arteries. While cardiothoracic centres have made network arrangements to coordinate care for the repair of type A dissections, a similar plan for vascular care is lacking. This study investigates early outcomes in patients with ruptured suprarenal aortic aneurysm or dissection (rSRAD) transferred to a specialist centre.

METHODS Retrospective observational study over a five-year period (2009–2014) assessing outcomes of patients with ruptured rSRAD diagnosed at their local hospital and then transferred to a tertiary centre capable of offering such treatment.

RESULTS Fifty-two patients (median age 73 years, 32 male) with rSRAD were transferred and a further four died during transit. The mean distance of patient transfer was 35 miles (range 4–211 miles). One patient did not undergo intervention due to frailty and two died before reaching the operating theatre. A total of 23 patients underwent endovascular repair, 9 hybrid repair and 17 open surgery. Median follow-up was 12 months (range 1–43 months). Complications included paraplegia ($n = 3$), stroke ($n = 2$), type IA endoleak ($n = 4$); 30-day and in-hospital mortality were 16% and 27%. For patients discharged alive from hospital, one-year survival was 67%.

CONCLUSIONS Although the number of patients with rSRAD is low and those who are transferred alive are a self-selecting group, this study suggests that transfer of such patients to a specialist vascular centre is associated with acceptable mortality rates following emergency complex aortic repair.

KEYWORDS

Aortic aneurysm – Aortic dissection – Ruptured aorta – Outcomes – Endovascular

Accepted 3 December 2017

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Introduction

Demonstration of strong volume–outcome relationships in vascular surgical procedures has driven reorganisation of UK vascular services, creating a ‘hub and spoke’ model, with satellite units referring appropriate cases into regional specialist vascular centres.^{1,2}

Studies suggest that transfer of patients with ruptured abdominal aortic aneurysm (rAAA) to a regional vascular centre is safe, with overall improvements in survival, rather than an excess of deaths during transfer.^{3,4} There is emerging evidence that endovascular repair of rAAA has benefits over open repair, particular if performed under local anaesthesia.^{5,6}

There is good evidence to suggest a volume–outcome relationship for infrarenal aortic aneurysm repair.² Although there are no published data on volume–outcome relationships for complex aortic aneurysm repair, a 2013 study from the United States suggests that the risk of mortality

approximately doubles in patients who undergo emergency surgery for acute aortic dissection in low-volume centres as compared with high-volume centres and it is reasonable to suppose a similar relationship for ruptured suprarenal aneurysm repair hold true.⁷

Currently within the UK there is no formal designation of supraregional centres for treatment of complex aortic disease or protocol referral pathways within networks for such patients, with the exception of Scotland where there is a designated National Service for thoracoabdominal aortic disease in Edinburgh. Results of open surgical repair of complex aortic pathology in the elective setting vary with disease extent; recent advances in endovascular technology have increased treatment options in this patient group, with evidence suggesting that endovascular repair is associated with reduced peri-operative mortality.^{8–10} However, relatively little is known about outcomes in patients with ruptured suprarenal aorta in the modern endovascular era.

The objective of this study was to evaluate perioperative and early outcomes in patients with ruptured suprarenal aneurysm or dissection (rSRAD; for the purposes of this study, defined as affecting any segment of aorta at or above the renal arteries, including juxtarenal, thoracoabdominal Crawford extent I–V and arch aortic disease) transferred to a specialist vascular centre.

Materials and methods

The UK National Research Ethics Service confirmed that ethical approval was not required for this study. Data were collected using a prospectively maintained database for patients referred to the Imperial Vascular Unit, St Mary's Hospital, London, for complex aortic repair for rupture over a five-year period (August 2009 to end July 2014). Patients who were transferred from outlying hospitals into the regional vascular unit with rupture of the aorta above the renal arteries were identified and retrospective analysis performed. We included patients with rupture secondary to any pathology (aneurysm, dissection, penetrating ulcer, intramural haematoma). Rupture was defined as evidence of haematoma or free blood on preoperative computed tomography (CT) imaging or at open surgery. Demographic, referral, operative and outcome data were confirmed by review of electronic and paper medical records. Postoperative myocardial infarction was defined as a rise in serum troponin or electrocardiographic changes. Respiratory complications included lower respiratory tract infection requiring intravenous antibiotics, effusion requiring chest drain insertion and need for prolonged ventilatory support. Renal failure was defined as a rise greater than 150% in serum creatinine concentration or requirement for renal replacement therapy. Postoperative paraplegia and stroke were confirmed by clinical review by a neurologist and CT or magnetic resonance imaging (MRI) imaging as appropriate.

Type of aortic repair performed was at the discretion of the lead surgeon. However, in principle, a total endovascular repair is preferred whenever possible, with hybrid or open repair performed when suitable aortic stentgrafts are not available or haemodynamic instability mandates an emergency aortic cross clamp.

All patients underwent preoperative CT angiography, the initial scan being performed at the referring centre in the majority of cases. The study unit offers a 24-hour on-call vascular interventional radiology and vascular surgical service, including vascular anaesthetists and intensive care specialists. Endovascular procedures are carried out by a team of vascular surgeons and vascular interventional radiologists with access to both a hybrid angiography suite and a mobile C-arm in main operating theatres. Spinal cord protection with spinal drain insertion is used at surgeon discretion, based on length of aortic coverage. All patients receive prophylactic intravenous antibiotics (1 g vancomycin and 1.5 g cefuroxime, unless contraindicated). The use of intravenous heparin (5000 units initially, with further doses to maintain an activated clotting time of 250–350 seconds) is at the surgeon's discretion. Point of care thromboelastography is available in theatres and is used to guide administration of

fresh frozen plasma, cryoprecipitate and platelets. Cell salvage with autotransfusion of processed blood is also available. Immediate postoperative care is given either in the intensive care unit or a dedicated vascular surgery high dependency unit. Endovascular aortic stentgrafts were chosen according to patient anatomy and surgeon preference from a consignment stock of Medtronic and Gore in appropriate sizes.

Following hospital discharge, patients who underwent open surgical repair were routinely reviewed in outpatient clinics at six weeks, with selective imaging and further clinical follow-up at the discretion of the operating surgeon. Those who underwent endovascular repair received surveillance CT imaging within the first six weeks, followed by outpatient clinical examination at six weeks. Our surveillance protocol then consists of CT imaging and clinical examination at six months and then on an annual or two-yearly basis thereafter.

Continuous variables are summarised as median and ranges and categorical variables as counts and percentages. Transfer distances were calculated using Google Maps, citing the shortest road route from referring hospital to our centre.

Results

Demographics and pathology

Fifty-two patients (median age 73 years, range 24–84 years; 32 male) with rSRAD were transferred to our centre during the study period. Pathology included arch aneurysm ($n = 1$, 2%); descending thoracic aneurysm ($n = 12$, 23%; including 1 mycotic aneurysm and 3 saccular aneurysms); Crawford extent I ($n = 1$, 2%), II ($n = 13$, 25%), III ($n = 3$, 6%), IV ($n = 6$, 12%; including 1 mycotic aneurysm); juxtarenal aneurysm ($n = 6$, 12%); type B dissection ($n = 5$, 10%); penetrating aortic ulcer ($n = 2$, 4%; including 1 mycotic ulcer); intramural haematoma ($n = 2$, 4%); traumatic thoracic aortic transection ($n = 1$, 2%). Six patients (12%) had undergone previous aortic surgery. Patient demographics are detailed in Table 1.

Transfer distances

During the study period, patients with rSRAD were transferred from 25 hospitals (Fig 1). The mean distance of patient transfer was 35 miles (range 4–211 miles). In addition to the 52 patients who were successfully transferred, a further four patients died during transit, including one patient who had an attempted transfer by helicopter. The transit distance of these four patients ranged from 38 to 189 miles. Of the patients who arrived at our centre, one patient did not undergo intervention due to frailty and two died before reaching the operating theatre.

Operative details

Seventeen patients (35%) were treated with open surgery. Juxtarenal aneurysm repair was defined as needing an anterior approach with a cross clamp above the renal arteries. Type IV repair was defined as needing a medial visceral rotation and cross clamp above the coeliac axis. Types I–III

Table 1 Patient demographics and aortic pathology of 52 patients (median age 73 years, range 24–84 years).		
Factor	Patients	
	(n)	(%)
Sex ratio (male : female)	32 : 20	
Cardiac disease ^a	13	25
Previous stroke	3	6
Chronic obstructive pulmonary disease	13	25
Chronic kidney disease	10	19
Diabetes	9	17
Smoking history:	13	25
Current smoker	16	31
Ex-smoker		
Connective tissue disease	3	6
Peripheral vascular disease	9	17
Previous aortic surgery	6	12
<i>Aortic pathology</i>		
Arch aneurysm	1	2
Descending thoracic aneurysm	12	23
Thoracoabdominal aneurysm; Crawford extent:		
I	1	2
II	13	25
III	3	6
IV	6	12
Juxtarenal aneurysm	6	12
Type B dissection	5	10
Penetrating aortic ulcer	2	4
Intramural haematoma	2	4
Traumatic dissection	1	2
^a Angina, previous myocardial infarction, coronary artery bypass, stents		

repairs were performed via a thoracotomy with a cross-clamp above the aneurysmal segment in the descending thoracic aorta. Twenty-three (47%) patients underwent endovascular repair and further nine had hybrid (open and endovascular) procedures (18%; 7 visceral, 2 arch). Three (6%) patients had chimney stentgrafts inserted: these were to the innominate artery in two patients and to the renal and superior mesenteric arteries in one patient. Three (6%) patients had aortic repair under locoregional anaesthesia and 26 (53%) had spinal drains inserted in theatres. Of those undergoing endovascular or hybrid repair, stentgraft access was via femorals in 23 (72%), iliac conduit in 4 (13%), axillary conduit in 2 (6%), and aortic conduit in 3 (9%).

Median duration of anaesthesia was 240 minutes (interquartile range, IQR, 180–360 minutes). Patients received a median of 7 units (IQR 4–9 units) of packed red blood cells in

Figure 1 Map of referring hospitals for patients with ruptured suprarenal aortic aneurysm or dissection transferred to St Mary's Hospital, London

addition to cell salvage autotransfusion. Twenty-five (51%) patients required admission to intensive care postoperatively; median length of stay was four days (IQR 2–10 days). All other patients were admitted to the vascular high-dependency unit for at least one night following aortic repair. Median length of hospital stay was 17 days (IQR 12–23 days).

Mortality and complications

Of the 49 patients who underwent aortic repair, 8 died within 30 days (mortality rate 16%); 7 of these patients had ruptured thoracoabdominal aneurysms (5 extent II, 1 extent III and 1 extent IV). The remaining patient had a ruptured distal arch aneurysm. Two patients underwent open surgical repair, one had a thoracic endograft inserted and five underwent hybrid operations (four visceral and one arch). One patient died during a return to theatre on the first day following a visceral hybrid repair for a ruptured extent II thoracoabdominal aneurysm. This patient required an aortic conduit and debranching of all four visceral vessels during the index operation. Subsequently, she developed bilateral renal artery thrombosis and lower-limb ischaemia and was returned to theatre for re-laparotomy and fasciotomies. One patient died after one day from cardiac arrest, one on day 2 from multiorgan failure following bowel ischaemia, one on day 3 following a myocardial infarction, one on day 10 from

respiratory failure, one on day 15 from multiorgan failure following bowel and renal ischaemia and one on day 17 from respiratory arrest. Complications are summarised in Table 2.

Overall, almost 50% (24 of 49 patients) of patients who underwent repair had a major postoperative complication. Many of these had more than one complication, often with one significant complication leading to others. Six patients (12%) had a myocardial infarction in the early postoperative period and one patient had a cardiac arrest in theatre but was successfully resuscitated. Thirteen patients (26%) had a respiratory complication, including six who required prolonged invasive or noninvasive ventilation. Four patients (8%) required renal replacement therapy: two died in hospital, one patient who underwent open surgical repair of an extent IV thoracoabdominal aneurysm required a ureteric stent. Both of the surviving patients were dialysis free at last follow-up. Three patients (6%) had bowel ischaemia: all underwent laparotomy and colectomy and two subsequently died. Three patients (6%) had lower-limb ischaemia; all died in hospital. Five patients (10%) had a neurological complication. Two patients had strokes: one patient died in hospital on the 12th postoperative day following an arch hybrid repair and the other was discharged home following an endovascular thoracic stentgraft and died after six months. Three patients had paraplegia: one patient died in hospital on the 15th postoperative day following a visceral hybrid repair, one patient was discharged to a rehabilitation facility having also undergone a visceral hybrid repair and one patient who underwent an endovascular thoracic stentgraft was discharged home and subsequently recovered enough function to walk with aids.

Nine patients (18%) required a secondary operation: four patients underwent laparotomy, three for bowel ischaemia and one for bleeding from the common iliac artery; four patients had extension of their thoracic

endovascular stentgraft for a proximal endoleak (one patient required a left carotid–subclavian bypass and one patient a carotid–carotid bypass and chimney stent to the innominate artery); and one patient underwent surgery to repair an oesophageal-aortic fistula one month after the index procedure.

A further five patients died in hospital; overall in-hospital mortality was 27%. Median follow-up was 12 months (range 1–43 months). The survival of patients followed for at least one year was 57% (24 of 42 patients), including early deaths. Of the 36 patients who were discharged from hospital alive, one-year survival was 67%.

Discussion

Successful treatment of patients presenting with rSRAD is challenging and has in the past been associated with poor outcomes. In the era before suprarenal endovascular technology, perioperative mortality rates for patients with ruptured thoracic or thoracoabdominal aneurysm of 48–60% were reported, with one-year survival of 38.5%.^{11,12} While this paper describes a heterogenous patient cohort, the common theme is that each patient was unable to be treated at the first hospital they presented to, even though all offered standard vascular services. This study suggests that transfer of patients with rSRAD is safe and that reasonable outcomes can now be achieved in such patients transferred to a regional vascular centre that offers both open surgical and endovascular repair for complex aortic aneurysm and dissection. The early and one-year mortality rate in this series of rSRAD compares well with that for ruptured infrarenal aortic aneurysm repair confirming that it is a viable treatment option in selected cases.^{5,6} Although those patients who survive transfer are a self-selecting group, we report a satisfactory one-year survival rate, at 57%.

Rapid advances in thoracic aortic endovascular technology and availability of off-the-shelf branched stentgrafts, together with parallel graft techniques (chimneys, snorkels, sandwiches), have widened the possibilities for treatment of patients with rSRAD and may offer improved early outcomes over open repair. A meta-analysis of patients undergoing repair for ruptured descending thoracic aneurysm suggests significant benefit associated with thoracic endovascular aortic repair (TEVAR) over open surgery, with 30-day mortality of 19% and 33%, respectively.¹³ A 2014 population-based analysis from the United States reported a decrease in operative mortality for ruptured descending thoracic aneurysm from 53% to 23%, associated with increased use of TEVAR.¹⁴ However, data on elective TEVAR suggest that the early survival benefits are eroded in the midterm due to cardiorespiratory morbidity and other selection bias (e.g. older, frailer patients tend to be offered endovascular repair over open repair).^{9,15}

As this report illustrates, the treatment of patients with rSRAD is resource heavy, requiring concentration of facilities and expertise to enable the optimal choice of open, endovascular or hybrid aortic repair to be selected depending on the needs of an individual patient. Of equal importance is the round-the-clock availability specialised allied

Table 2 Postoperative complications of 49 patients.		
Complication	Patients	
	(n)	(%)
Cardiac:		
Myocardial infarction	6	12
Cardiac arrest	1	2
Respiratory	13	26
Renal:		
Acute kidney injury	11	2
Renal replacement therapy	4	8
Visceral ischaemia	3	6
Lower limb ischaemia	3	6
Stroke	2	4
Paraplegia	3	6
Reoperation	9	18

services, from anaesthetists and intensivists with experience in the care of patients with complex aortic disease. Nearly 50% of the patients in this series underwent endovascular repair and a further 28% underwent hybrid procedures, emphasising the need for fully staffed modern hybrid suites that combine theatre environments with fixed imaging capabilities. The majority of patients required intensive care, some for prolonged periods, and one in five needed to return to theatre for further intervention.

A hub-and-spoke arrangement for the provision of vascular services has matured based on the criteria set out in the *Provision of Vascular Services* document.¹ This document defines the elective and emergent needs of a population and advises how and where the majority of vascular patients should be cared for. However, not all scenarios are covered and arrangements for the care of patients with ruptured complex aortic conditions (being both rare and with an uncertain outcome) are beyond the intended remit. The UK has lagged behind the United States in terms of creating and designating supraregional centres to undertake complex aortic repair. To date, commissioning of complex aortic services has focused on complex endovascular stent grafts for abdominal aortic aneurysms.¹⁶ Provider units are required to have catchment populations in excess of 2.4 million and have performed at least 40 cases, with availability of regular multidisciplinary team meetings and personnel to include vascular surgeons, vascular interventional radiologists, cardiothoracic surgeons (where appropriate), anaesthetists with vascular experience, vascular scientists, theatre nurses and radiographers (with specific vascular experience) and specialist nurses. It is projected that only 10–20 centres will be required throughout the country. Although criteria for centres undertaking repair of thoracic aortic disease have yet to be published, it is likely that fewer centres will be required, given the incidence of thoracic aortic disease. A 2014 study suggests that outcomes for patients with rAAA are superior in teaching hospitals with larger bed capacities and a greater proportion of cases performed endovascularly.¹⁷ It would be expected that only the largest centres that are able to offer full open and endovascular surgery skills and facilities should treat patients with rSRAD.

Some of the lessons learnt over the study period have been used to further improve care for this group of patients. We would always aim to first accept any referral and then to review imaging sent by image exchange portal while patients are prepared for transfer. Patients refusing further treatment, those who are moribund or haemodynamically unstable and unresponsive to fluid resuscitation are obviously not candidates for transfer. Patients over 100 miles away should be transferred by helicopter where possible and a medical escort should be encouraged to attend all transfers if available. Patients should not wait for anaesthetic assessments, further imaging or blood cross-matching at the local referring centre, since this introduces unnecessary delays. On arrival, patients need to be met in the resuscitation room of the emergency department and be rapidly assessed by both surgical and anaesthetic teams with rapid liaison with the intensive care unit, as appropriate. Some

patients require immediate transfer to theatre, while others may benefit from a period of physiological optimisation and undergo surgery on the next day's vascular list, with the advantage of expertise from a larger team. Prioritisation of cases and flexibility with colleagues is vital to achieve optimum treatment for such patients.

This study is limited by the size of the patient cohort, the use of data from a single centre and retrospective analysis. However, there are very few published reports on outcomes following rSRAD and this paper represents the largest contemporary series. The turnaround rate for patients with rSRAD is not addressed in this study. We suspect that some patients are turned down without referral to specialist centres, due in part to the perception that aortic repair has poor outcomes in this cohort and in part to the lack of identified national centres and pathways.

Although the number of patients with rSRAD is low and those who are transferred alive are a self-selecting group, this study suggests that transfer of such patients to a specialist vascular centre is associated with acceptable early outcomes following emergency complex aortic repair. Further centralisation of vascular services for such procedures would be expected to define catchment areas, streamline referral pathways and increase volumes at supraregional centres, with the expectation of improved access to intervention and better outcomes.

Acknowledgements

The research was supported by the National Institute of Health Research Biomedical Research Centre based at Imperial College Healthcare NHS Trust and Imperial College London. This paper was presented at the Charing Cross International Symposium 2015, London, UK.

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