Outcome of open Repair of Ruptured Thoracoabdominal Aortic Aneurysms. A Systematic Review and Meta-Analysis

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Abstract:

Introduction-Aim: Rupture is the most lethal complication in untreated cases of thoracoabdominal aortic aneurysms (TAAAs). We performed a systematic review and meta-analysis attempting to identify all published reports on ruptured thoracoabdominal aortic aneurysms (rTAAs) treated with open repair with the aim to assess the mortality rate and common complications.

Methods: We used the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines. A thorough search of the English-language literature published until January 2019 was performed to identify studies relative to ruptured TAAAs. Data extracted from the eligible studies, included first author's name, study year, type of study, total number of patients with rTAA, number of deaths, mean age and mean follow-up period.

Results: Overall, 16 articles were included in the meta-analysis after application of inclusion and exclusion criteria. A total of 1,036 patients with ruptured aneurysms were included in the present analysis. Pooled mortality rate after open repair of rTAAs from all 16 studies was 33.40% (95%CI=22.60-45.07; I2=92.5%, p<0.001). When we pooled data only from four studies reporting data exclusively on rTAA, the pooled mortality rate was 47.77% (95% CI=32.71-63.04, I2=84.4%, p<0.001). Furthermore, we found a statistically significant decreasing trend in mortality rates over time (Q=4.13, p<0.04) Cardiac event rate was 8.79% (95% CI=1.55-20.20, I2=85.81%, p<0.001), pooled permanent paraplegia was estimated at 5.56% (95%CI=1.76-10.96) pooled stroke rate was 1.61% (95%CI=0.01-6.67; I2=43.29%, p=0.17) and re-intervention rate was 8.33% (95%CI=2.86-15.82).

Conclusions: Rupture is a lethal complication in untreated cases of TAAAs and it is associated with an approximately 50% mortality rate. Young and fit patients with contained rupture who are not shocked on presentation might have a better outcome, especially if transferred in experienced centers.

INTRODUCTION

Open repair of thoracoabdominal aortic aneurysms (TAAs) remains a technically demanding operation. Adjunctive strategies especially used in the era of organ protection, have improved the outcome of these patients and have reduced the occurrence of paraplegia, renal failure, and mesenteric ischemia. These strategies include distal aortic perfusion with left heart bypass, cerebrospinal fluid drainage, and intercostal artery reimplantation. However, despite the advances in open surgical techniques, the morbidity and mortality rates for the treatment of TAAs continue to remain considerably high. In a recent metanalysis, the pooled mortality rate among patients with TAAAs treated electively was 11.3%.[1] This metanalysis also estimated a pooled spinal cord ischemia rate of 8.3%, a stroke rate of 3.1%, whereas the need for permanent dialysis rate was 7.9%.[1]

Rupture is the most lethal complication in untreated cases of TAAAs. Nationwide clinical data derived from the inpatient sample on patients who underwent repair of a ruptured TAAA from 1988 to 1998 in the USA showed an overall surgical mortality of 53.8%.2 The renal failure (28%) and the cardiac complications (18%) were the most common complications. In this context, we performed a systematic review and meta-analysis attempting to identify all published reports on ruptured TAAs (rTAAs) treated with open repair with the aim to assess the mortality rate and common complications.

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Authors	Journal / Year	Study period	TOTAL Patients	Mean age (years)	Number of r- TAAA (n)/%	Technique	Organ protection
Murana et al	European Journal of Cardio-Thoracic Surgery, 2015	1994-2014	542	65	48/8.9%	LSHB(87.3%) / CPB+DHCA(occasionally)	Sequential aortic clamping/ CSFD/SSEP&MEP/ Reattachment of intercostal arteries
Coselli et al	The Journal of Thoracic and Cardiovascular Surgery,2015	1986-2014	3309	67	170/ (5.1%)	LSHB/MHCA/ DHCA(Rarely)	Cold crystalloid perfusion/ selective visceral perfusion/ Reattachment of intercostal arteries/CSFD
Zanetti et al	Kardiochirurgia I Torakochirurgia Polska, 2015	1994-2014	51	62	51/100%	LSHB (50%) / CPB+FFB (15.6%)/ CS (13.7%)/ CPB+DHCA (19.6%)	DHCA/CSFD//Reattachment of intercostal arteries
Youssef et al.	J Vasc Surgery,2015	1998- 2012	62	66	15/24.2%	CPB/PCPB/ LSHB	CSFD/SSEP&MEP Cold crystalloid perfusion/ selective visceral perfusion
Fukui et al	Ann Vasc Surg, 2015	2009-2015	44	65	6/13.6%	CPB (100%)	MHCA/DHCA /Sequential aortic clamping/Reattachment of intercostal arteries/ cold crystalloid perfusion/ selective visceral perfusion/ CSFD
Gaudino et al	The Journal of Thoracic and Cardiovascular Surgery, 2015	1997-2014	57	67.2	57/100%	CS (82.4%)/ PCB(15.7%)/ CPB+DHCA (1.7%)	Cold crystalloid perfusion/ selective visceral perfusion/ Reattachment of intercostal arteries/CSFD
Conrad et al.	Ann Thorac Surg,2007	1997-2005	455	71.1	52/ (11.4%)	CS+DAP (92%)	CSFD/ Reattachment of intercostal arteries
Rigberg et al	J Vasc Surgery,2006	1991-2002	1010	72	213/ (21%)	NR	NR
Cowan et al	J Vasc Surgery,2003	1988-1998	321	71.5	321/ (100%)	NR	NR
Dardik et al.	J Vasc Surgery,2002	1992-2001	257	66	17(6.6%)	LSHB / MHCA	/CSFD/sequential clamping/ reattachment of intercostal arteries
Cina' et al	Ann Vasc Surg,2002	1990-2001	121	69	22/ (18.1%)	CS+ Gott shunt/LSHB	CSFD/sequential clamping/ reattachment of intercostal arteries
Bradbury et al	Eur J Vasc Endovasc Surg,1999	1983-1996	23	71.3	23/ (100%)	NR	NR
Ross et al	The Journal of Thoracic and Cardiovascular Surgery, 1998	1987-1997	132	NR	21/15.9%	CS (100%)	Reattachment of intercostal arteries
Grabitz	J Vasc Surgery,1996		260	63	38(14.6%)	CS (100%)	Reattachment of intercostal arteries, SSEP&MEP
Svensson et al (Safi H.J)	J Vasc Surgery,1993	1960-1991	1679	66	61/(4.0%)	CS(83%)/ LSHB(17%)	Reattachment of intercostal arteries
Cox et al.	J Vasc Surgery,1992	1966-1991	129	66	24(75%)	CS	CSFD /Cold crystalloid perfusion/selective visceral perfusion/Reattachment of intercostal arteries

Table 1: Overall, 16 studies were included in the meta-analysis after application of inclusion and exclusion criteria.

CPB: cardio-pulmonary bypass, PCPB: Partial cardio-pulmonary bypass,LSHB: left-side heart bypass, CS: clamp and sew, PLSFFB: partial left sided femoro-femoro bypass,DHCA: Deep hypotermic cardiocirculatory arrest, MHCA: Moderate hypotermic cardiocircylatory arrest, CSFD: Cerebro-spinal fluid drainage, ICAs: Intercostal arteries,MEP/SSEP: motor-evocated potentials/somato-sensory evocated potentials.

MATERIALS AND METHODS

We used the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines. Medical databases included Medline, Scopus, EMBASE, Google Scholar, Ovid and the Cochrane Library were investigated, while we also searched manually the reference lists of the eligible articles for additional articles. Keyword algorithm included “thoraco-abdominal” AND “thoraco-abdominal” OR “aortic aneurysms” OR “open repair” OR “ruptured.” Our main interest focused in studies, published in English, reporting mortality rates after open repair of ruptured thoracoabdominal aneurysms.

A thorough search of the English-language literature published until January 2019 was performed to identify studies relative to ruptured TAAAs.

Studies were included in the review if they:

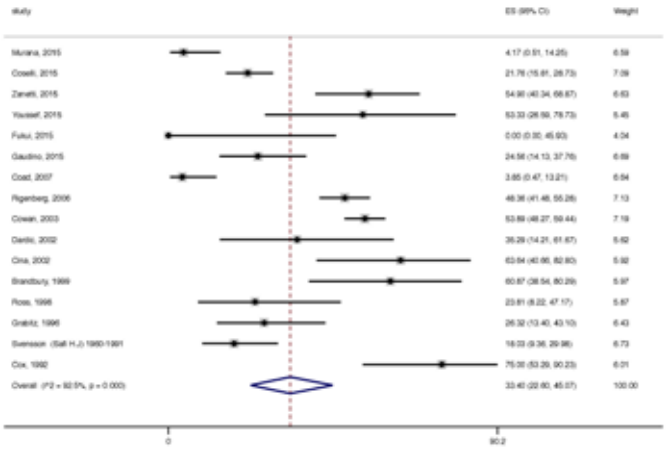
- Provided detailed data on open repair of TAAAs;
- Presented data of the in-hospital mortality
- Described >20 patients
- Were published in the English language
- Articles were excluded if they:
- Reported non ruptured TAAAs;
- Reported data for hybrid or endovascular reconstructions;
- Referred to treatment of infected TAAAs;

Two authors (GK, CNA) independently extracted and analyzed data and the final decision was reached by consensus. Data extracted from the eligible studies, included first author’s name, study year, type of study, total number of patients with rTAA, mean age, number of deaths, complications (if described). We thereafter calculated mortality rates in patients with rTAA (number of deaths / total number of patients) for each eligible study. We expressed the rates as proportions and 95% confidence intervals (95% CIs). We transformed the values into quantities according to the Freeman-Tukey variant of the arcsine square root transformed proportion and the pooled mortality was calculated as the back-transformation of the weighted mean of the transformed proportion, using DerSimonian-Laird weights of random effects model and expressed as % proportion.

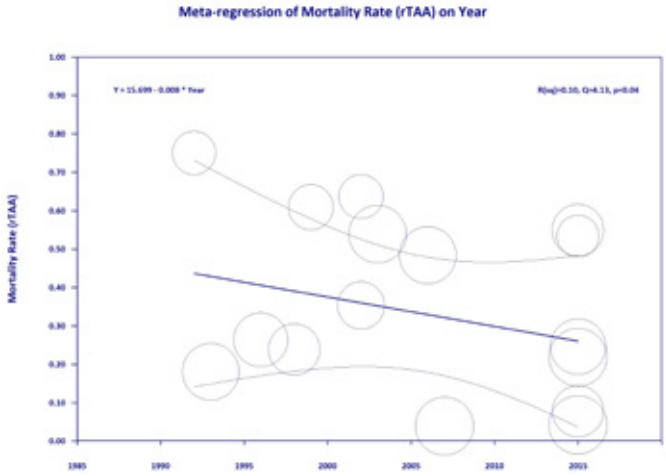
We also performed a second analysis deriving pooled mortality rates after excluding three studies with very low mortality rates (<15%; sensitivity analysis). A methodological quality assessment of the selected studies and analysis of heterogeneity and publication bias was performed. A meta-regression analysis with mortality rates over time as a covariate was performed in order to explore potential time trend upon mortality rates.

RESULTS

Our literature review identified a total of 16 articles 2-17 to be included in the meta-analysis after application of inclusion and exclusion criteria (Table 1). A total of 1,036 patients with ruptured aneurysms were included in the present analysis. An Egger’s regression analysis did not reveal significant publication bias (int = 3.36, p=0.07) among the eligible studies. Pooled mortality rate after open repair of rTAAs from all 16 studies was 33.40% (95%CI=22.60-45.07; I2=92.5%, p<0.001; Figure 1).



Furthermore, we found a statistically significant decreasing trend in mortality rates over time (Q=4.13, p<0.04; Figure 2).



We performed a meta-regression analysis with total number of ruptured only cases per study as a covariate, which did not reveal significant association with mortality rate. However, a meta-regression analysis with total number of patients per study (elective and ruptured) revealed a significant reverse association between mortality rate and caseload (Q=4.13, p=0.04). This is a potential indicator that busiest departments dealing with larger number of elective and ruptured TAAs presented with better results in terms of mortality after rTAA repair.

Sensitivity analysis evidenced a pooled mortality rate of 41.73% (95%CI=31.68 – 52.13, I^2=88.8%, p<0.001), after exclusion of three studies reporting mortality rates <15%.[3,7,9] A second sensitivity analysis after exclusion of the study by Cowan et.al. showed a pooled mortality rate of 31.83% (95%CI=20.68-44.06, I^2=90.9%, p<0.001) from the remaining 15 studies.

When we pooled data only from four studies reporting

data exclusively on rTAA, the pooled mortality rate was 47.77% (95% CI=32.71-63.04, I^2=84.4%, p<0.001).[2,5,8,13] Additionally, when we considered morbidity data from only these four studies, pooled cardiac event rate was 8.79% (95% CI=1.55-20.20, I^2=85.81%, p<0.001; data from all four studies), pooled permanent paraplegia was estimated at 5.56% (95%CI=1.76-10.96)[5,8] pooled stroke rate was 1.61% (95%CI=0.01-6.67; I^2=43.29%, p=0.17)[5,8] and reintervention rate was 8.33% (95%CI=2.86-15.82) [5,8] In the paper by Cowan et al. acute renal failure (28.0%) and cardiac-related events (18.1%) were the most common complications. More than half (51.2%) of all deaths occurred within 24 hours after surgery.

DISCUSSION

We reviewed 1,036 patients, with ruptured aneurysms, and we found an overall in-hospital mortality rate of 33.4% independently of the type of aneurysm. Interestingly, when we analyzed the data from four studies reporting exclusively the outcomes on ruptured TAAs, the pooled mortality rate was 47.77%.[2,5,8,13] The study of Cowan et al using national data from the Nationwide Inpatient Sample, reported the largest number of patients with 321 ruptured aneurysms and found an overall "real-world" mortality rate of 53.8%.[2] Regarding the morbidity associated with the technique, data from the four studies reporting the outcome exclusively for ruptured aneurysms, showed that the cardiac event rate was 8.8%, the permanent paraplegia was estimated at 5.6%, pooled stroke rate was 1.6% and re-intervention rate was 8.3% [2,5,8,13]

We found a relatively high heterogeneity between the analyzed studies. This can be explained by whether the rupture was contained or free and by the presence of haemodynamic instability. Although it is known that contained ruptures have a better outcome compared to free ruptures,[17] unfortunately, no specific data categorizing the patients according to the haemodynamic status were provided by the eligible studies. In addition, the heterogeneity can also be explained by the diversity in surgeon's team case load and familiarity with the procedure among the studies but it was also related to the institution's experience in managing the perioperative care of these challenging cases.[2] A trend of lower mortality in high-volume centers was shown in our study. Coselli et al reported a 21.5% mortality rate while Svensson et al reported a 18% mortality occurrence.[4,16]

A recent metanalysis showed that the pooled mortality rate among patients with unruptured TAAAs treated electively was 11.3%.[1] Our study provides evidence that the mortality for open reconstruction in rTAAs is 3 to 5-fold higher than the mortality in unruptured aneurysms. Previous studies have questioned whether repair is worthwhile in all ruptured cases. It has been suggested that patients in shock with a Crawford type II aneurysm have a poor prognosis and that intervention should be offered only in the most favorable of these cases.[13] Patients with types III or IV contained rupture who are not shocked on presentation might have a better outcome, especially if transferred in experienced centers. Validation of prognostic scoring systems for ruptured TAAs is lacking. However, clinical experience has shown that free rupture, patient's overall deteriorated functional status, advanced age > 76 years, preoperative cardiac arrest and loss of consciousness are independent predictors of high risk of death.[2,5,8,13] It should also considered that patients presenting with impending rupture, represent a high-risk subgroup, having probably denied elective repair because of associated comorbidities.[18] In the paper by Cox et al. none of the patients with free rupture or with preoperative hypotension or cardiac arrest survived.[17] Other studies showed that age > 77 years, female gender and preoperative renal dysfunction were also independent risk factors for increased mortality.[2,8]

Regarding the complications rate in patients with rTAAAs, more than half (51.7%) presented with at least one postoperative complication.[2] Acute renal failure of 28.0% and cardiac-related events of 18.1% were the most common complications in patients who survived from open surgery.[2] More than half (51.2%) of all deaths occurred within 24 hours after surgery. Uncontrolled bleeding from dilutional coagulopathy caused by massive blood loss and multiple organ failure were the most common causes of death. [2,5,8,13]

Interestingly, we found a statistically significant decreasing trend in mortality rates over time. This finding can be explained by the evolution and improvements in surgical technique over time and the use of adjunct measures for organ protection such as distal aortic perfusion with left heart bypass, cerebrospinal fluid drainage, and intercostal artery reimplantation. This study has limitations. Only a few studies reporting outcomes exclusively for rTAAAs have been reported in the literature. No detailed data for the type of aneurysm and the outcome were described in the majority of the studies. In addition, only a few studies specified complications for ruptured TAAs.Selection bias or referral patterns of ruptures may have skewed these results.

In conclusion, rupture is a lethal complication in untreated cases of TAAAs. It is associated with an approximately 50% mortality rate. Young and fit patients with contained rupture who are not shocked on presentation might have a better outcome, especially if transferred in experienced centers.

No conflict of interest.

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