ΔΙΑΚΡΑΤΙΚΟ ΜΕΤΑΠΤΥΧΙΑΚΟ ΠΡΟΓΡΑΜΜΑ ΣΠΟΥΔΩΝ:

«Ενδαγγειακές Τεχνικές»

ΕΘΝΙΚΟ ΚΑΙ ΚΑΠΟΔΙΣΤΡΙΑΚΟ ΠΑΝΕΠΙΣΤΗΜΙΟ ΑΘΗΝΩΝ ΙΑΤΡΙΚΗ ΣΧΟΛΗ
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ΔΙΠΛΩΜΑΤΙΚΗ ΕΡΓΑΣΙΑ

ΘΕΜΑ:

Rupture after EVAR and EVAR for rupture: an interactive relation

ΜΕΤΑΠΤΥΧΙΑΚΟΣ ΦΟΙΤΗΤΗΣ

ΑΝΤΩΝΟΠΟΥΛΟΣ Ν. ΚΩΝΣΤΑΝΤΙΝΟΣ

ΑΘΗΝΑ

ΙΑΝΟΥΑΡΙΟΣ, 2013

ΕΘΝΙΚΟ ΚΑΙ ΚΑΠΟΔΙΣΤΡΙΑΚΟ
ΠΑΝΕΠΙΣΤΗΜΙΟ ΑΘΗΝΩΝ
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ΠΡΑΚΤΙΚΟ ΚΡΙΣΕΩΣ

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Η Τριμελής Εξεταστική Επιτροπή η οποία ορίσθηκε από την ΓΣΕΣ της Ιατρικής Σχολής του Παν. Αθηνών Συνεδρίαση της 13ης Ιανουαρίου 2010 για την αξιολόγηση και εξέταση τ... υποψηφίου κ... ....., συνεδρίασε σήμερα 14/01/2011.

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Η εξεταστική επιτροπή αφού έλαβε υπ' όψιν το περιεχόμενο της εργασίας και τη συμβολή της στην επιστήμη, με ψήφους ..... προτείνει την απονομή στον παραπάνω Μεταπτυχιακό Φοιτητή την απονομή του Μεταπτυχιακού Διπλώματος Ειδίκευσης (Master's).

Στην ψηφοφορία για την βαθμολογία ο υποψήφιος έλαβε για τον βαθμό «ΑΡΙΣΤΑ» ψήφους ....., για τον βαθμό «ΛΙΑΝ ΚΑΛΩΣ» ψήφους ....., και για τον βαθμό «ΚΑΛΩΣ» ψήφους ..... Κατά συνέπεια, απονέμεται ο βαθμός «.....».

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Αφιερώνεται στην οικογένειά μου

Νίκο, Ευαγγελία και Βίκυ

AKNOWLEDGEMENTS

The author should specially thank Professor Christos D. Liapis[1], Associate Professor John D. Kakisis[1]and Assistant Professor Christos Klonaris[4] for supervising the preparation of the current thesis

The author should thank the following for their contribution to the preparation of the original article: Vasilios Andrikopoulos[2], Pavlos Antoniadis[3], Nikolaos Bessias[2], Konstantinos Dervisis[3], Sotirios Georgopoulos[4], Triantafillos G. Giannakopoulos[1], Athanasios Giannoukas[5], Elias Kaperonis[6], Dimitrios Kiskinis[7], Andreas Lazaris[1], Vasilios Papavasiliou[6], Vasilios Saleptsis[5], Nikolaos Saratzis[7], Konstantinos Seretis[1], Charalambos Tampakis[3]

The author should also thank the following for assisting in data collection: Nikolaos Degermetzoglou[7], Marina Kafeza[4], Ioannis Kotsikoris[2] and Dimitrios Liakopoulos[4]

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Title:

Rupture after EVAR and EVAR for rupture:

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Key Words (English): abdominal aortic aneurysm, rupture, mortality, Glasgow Aneurysm score, endovascular aortic repair, EVAR

Key Words (Greek): ανεύρυσμα κοιλιακής αορτής, ρήξη, θνητότητα, κλίμακα "Glasgow Aneurysm score", ενδαγγειακή αντιμετώπιση ανευρύσματος κοιλιακής αορτής, EVAR

Abbreviations: Abdominal aortic aneurysm (AAA), Case fatality rates (CFR), Chronic renal failure (CRF), Computed Tomographic Angiography (CTA), Coronary Artery Disease (CAD), Diabetes Mellitus (DM), EndoVascular Aortic Repair (EVAR), Glasgow Aneurysm Score (GAS), Nationwide Inpatient Sample (NIS), Number Needed to Treat (NNT), Open Surgical Repair (OSR), Receiver-Operator Characteristic (ROC), ruptured Abdominal Aortic Aneurysm (rAAA)

Abstract (English)

Introduction:

Endovascular aortic repair (EVAR) is being used with increasing frequency for the treatment of ruptured abdominal aortic aneurysms (rAAAs), though conflicting results have been reported concerning perioperative mortality. The aim of our study was to present a multi-centre experience in the treatment of rAAAs over a 6-year period in Greece and evaluate potential difference in mortality rates between EVAR and open technique. This study also aimed to evaluate the Glasgow Aneurysm Score (GAS) in predicting in-hospital mortality and present time trends of EVAR for rupture. A comprehensive review, including time trends, of all cases presenting with rupture after EVAR was also among the scopes of the study

Patients and Methods:

Prospectively collected data from seven public hospitals in Greece concerning rAAA repairs between January 2006 and April 2012 were retrospectively analyzed. Primary outcome was in-hospital mortality. Multivariate logistic regression analysis was used to identify independent risk factors.The receiver-operator characteristic (ROC) curve was used to determine the value of the GAS in predicting in-hospital death. Time trend analysis, depicting annual changes (%), concerning EVAR for rupture and rupture after EVAR was also conducted.

Results:

A total of 418 patients (92.3% males, mean age=74.3+/-8.8) with rAAAs were recorded during the study period. Among them, 113 patients (27%) underwent EVAR. Overall in-

hospital mortality was 45.2%, whereas in-hospital mortality after EVAR and open repair was 20.4% and 54.3%, respectively ($p<0.001$). Multivariate analysis evidenced that hemodynamic instability ($p<0.001$), open repair ($p<0.001$), older age ($p<0.001$), coronary artery disease ($p<0.001$) and renal insufficiency ($p=0.02$) independently increased in-hospital mortality. Area under the curve (AUC) was 0.80 (95%CI=0.75-0.85, $p<0.001$) for open repair and 0.64 (95%CI=0.51-0.77, $p=0.04$) for EVAR. History of previous abdominal aortic operation was recorded in 25 patients (6.0%). Among them, 22 patients (88.0%) had been treated with endovascular approach. Annual increase forproportion (%) of EVAR for rupture was 5% ($p=0.004$) and for rupture after EVAR was 2.5% ($p=0.005$).

Conclusions:

1. Although the two groups were not directly comparable, EVAR for rAAAs appears to be associated with lower mortality compared to open repair.
2. Rupture after EVAR is a clinical entity encountered with increasing frequency over the past few years, probably reflecting limitations of the method and the follow-up practice.
3. GAS may need to be appropriately modified for patients with EVAR for rAAA and rAAA after EVAR.

Abstract (Greek)

Εισαγωγή:

Η ενδαγγειακή αποκατάσταση ανευρύσματος κοιλιακής αορτής (EVAR) χρησιμοποιείται με αυξανόμενη συχνότητα τα τελευταία έτη για τη θεραπεία των ραγέντων ανευρυσμάτων κοιλιακής αορτής, παρά το γεγονός ότι αντιφατικά αποτελέσματα έχουν παρουσιαστεί στη βιβλιογραφία, σχετικά με τη διεγχειρητική θνητότητα της μεθόδου. Ο σκοπός της παρούσας μελέτης είναι να παρουσιάσει την πολυκεντρική 6ετή εμπειρία στη θεραπεία των ραγέντων ανευρυσμάτων στην Ελλάδα και να εκτιμήσει δυνητικές διαφορές στη θνητότητα μεταξύ της ενδαγγειακής και ανοιχτής χειρουργικής θεραπείας. Η μελέτη αυτή επίσης έχει σαν σκοπό να εκτιμήσει την κλίμακα " Glasgow Aneurysm Score, GAS" σχετικά με την πρόβλεψη της ενδονοσοκομειακής θνητότητας, καθώς επίσης και να παρουσιάσει τις διαχρονικές τάσεις της χρήσης της ενδαγγειακής τεχνικής για την αντιμετώπιση των ραγέντων ανευρυσμάτων της κοιλιακής αορτής. Τέλος, αναλυτική παρουσίαση των περιστατικών με ρήξη μετά από ενδαγγειακή αντιμετώπιση ανευρύσματος κοιλιακής αορτής, συμπεριλαμβανομένων και των διαχρονικών τάσεων, αποτελεί σκοπό της παρούσας μελέτης.

Ασθενείς και Μέθοδοι

Τα δεδομένα των ασθενών με ρήξη ανευρύσματος κοιλιακής αορτής μεταξύ Ιανουαρίου 2006 και Απριλίου 2012 από επτά Δημόσια Νοσοκομεία της Ελλάδος αναλύθηκαν αναδρομικά. Το κύριο αποτέλεσμα που αναλύθηκε ήταν η ενδονοσοκομειακή θνητότητα. Η μέθοδος της πολλαπλής λογιστικής παλινδρόμησης (multiple logistic regression)

χρησιμοποιήθηκε για την ανίχνευση ανεξάρτητων προγνωστικών παραγόντων. Η καμπύλη λειτουργικού χαρακτηριστικού δέκτη (Receiver Operating Characteristic, ROC) χρησιμοποιήθηκε για να υπολογίσει την αξία της κλίμακας "GAS" στην πρόβλεψη της ενδονοσοκομειακής θνητότητας. Πραγματοποιήθηκε επίσης, ανάλυση διαχρονικών τάσεων με τη μορφή των ποσοστιαίων (%) ετήσιων αλλαγών σχετικά με τη χρήση της ενδαγγειακής τεχνικής στα ραγέντα ανευρύσματα κοιλιακής αορτής, αλλά και τις ρήξεις ανευρυσμάτων κοιλιακής αορτής μετά από ενδαγγειακή τεχνική.

Αποτελέσματα

Συνολικά, συμμετείχαν 418 ασθενείς (92.3% άνδρες, μέση ηλικία=74.3+/-8.8 έτη) με ρήξη ανευρύσματος κοιλιακής αορτής. Ανάμεσα σε αυτούς, 113 ασθενείς (27%) αντιμετωπίστηκαν ενδαγγειακά. Η συνολική ενδονοσοκομειακή θνητότητα ήταν 45.2%, ενώ τα ποσοστά για την ενδαγγειακή και ανοιχτή θεραπεία ήταν 20.4% και 54.3%, αντίστοιχα ($p<0.001$). Η πολυπαραγοντική ανάλυση έδειξε ότι η αιμοδυναμική αστάθεια ($p<0.001$), η ανοιχτή αποκατάσταση ($p<0.001$), η αυξημένη ηλικία ($p<0.001$), η στεφανιαία νόσος ($p<0.001$) και η νεφρική ανεπάρκεια ($p=0.02$) ήταν ανεξάρτητοι προγνωστικοί παράγοντες της ενδονοσοκομειακής θνητότητας. Η επιφάνεια κάτω από την καμπύλη (area under the curve , AUC) ήταν 0.80 (95%CI=0.75-0.85, $p<0.001$) για την ανοιχτή και 0.64 (95%CI=0.51-0.77, $p=0.44$) για την ενδαγγειακή μέθοδο. Ιστορικό προηγηθείσας επέμβασης στην κοιλιακή αορτή καταγράφηκε σε 25 ασθενείς (6%). Ανάμεσα σε αυτούς, 22 ασθενείς (88.0%) είχαν αντιμετωπισθεί στο παρελθόν με ενδαγγειακή τεχνική. Η ετήσια (%) αύξηση της αναλογίας της χρήσης ενδαγγειακής θεραπείας για ρήξη ανευρύσματος κοιλιακής αορτής ήταν 5% ($p=0.004$) και της αναλογίας της ρήξης μετά από ενδαγγειακή θεραπεία ανευρύσματος κοιλιακής αορτής ήταν 2.5% ($p=0.005$).

Συμπεράσματα

1. Παρά το γεγονός ότι οι δύο ομάδες δεν ήταν απόλυτα συγκρίσιμες, η ενδαγγειακή αποκατάσταση ανευρύσματος κοιλιακής αορτής φαίνεται να σχετίζεται με χαμηλότερα ποσοστά θνητότητας, συγκριτικά με την ανοιχτή αποκατάσταση.
2. Η ρήξη μετά από ενδαγγειακή αποκατάσταση ανευρύσματος κοιλιακής αορτής παρατηρείται με ολοένα και αυξανόμενη συχνότητα τα τελευταία χρόνια, πιθανώς αντικατοπτρίζοντας περιορισμούς τόσο της ίδιας της τεχνικής, όσο και της παρακολούθησης των ασθενών της κατηγορίας αυτής.
3. Η κλίμακα "GAS" πιθανώς να χρειάζεται τροποποίηση όσον αφορά στους ασθενείς με ενδαγγειακή αντιμετώπιση ρήξης , αλλά και στη κατηγορία των ασθενών με ρήξη μετά από ενδαγγειακή αντιμετώπιση.

Introduction

Abdominal aortic aneurysm (AAA) represents a significant problem, carrying a relatively high mortality and morbidity (1-3). Ruptured AAAs (rAAAs) are fatal in 85% of the cases, whereas, 66% of these patients die before reaching hospital or without operation (3). Endovascular aortic repair (EVAR) has evidenced benefit over the open surgical repair (OSR) in the treatment of patients with intact AAAs. This has raised the question, whether the endovascular approach may also be applied after rupture (4).

The aim of the current multicenter study was to explore whether EVAR may be associated with lower mortality in patients with rAAA and explore potential independent risk factors for rupture. This study also aimed to evaluate Glasgow Aneurysm Score (GAS) in predicting in-hospital mortality among the Greek population and present time trends and correlation between EVAR for rupture and rupture after EVAR. A comprehensive review of all cases, presenting with rupture after endovascular repair was also among the scopes of this study.

Patients and Methods

Patients

A retrospective review of prospectively collected data for all consecutive patients presenting with rAAAs (infrarenal) between January 2006 and April 2012 was performed. Five sentinel tertiary referral hospitals in Athens ("Attikon University Hospital", "Kontantopoulio General Hospital, Agia Olga", "Laiko University Hospital", "Red Cross Hospital" and "Sismanoglio General Hospital") and two peripheral hospitals ("University Hospital of Larissa" and "Papageorgiou General Hospital in Thessaloniki) participated in the study. Free peritoneal blood in abdominal cavity or extra-aortic blood (or contrast medium) presence in Computed Tomographic Angiography (CTA) in patients with AAA was defined as rupture. Patients were treated with open or endovascular approach at the discretion of the attending vascular surgeon. Informed consent was provided from all patients or first degree relatives and corresponding hospital's ethics committee approved the protocol.

Variables of interest- exclusion criteria

Preoperative factors extracted from patients' medical records included age, sex, history of smoking, date of rupture, corresponding hospital, history and type of previous AAA repair, comorbidities (coronary artery disease; CAD, diabetes mellitus; DM, hypertension, chronic renal failure; CRF, previous stroke) and type of operation performed (EVAR or OSR). Hemodynamic instability was defined as systolic blood pressure <80mmHg on first attendance to the hospital and before the use of fluid resuscitation or blood/plasma transfusion. The primary outcome measure was in-hospital mortality. Stable patients had a

CTA before surgery, whereas unstable patients that did not respond rapidly to initial fluid resuscitation were transferred to the operating room. Exclusion criteria for EVAR were applied using conventional requirements for off-the-shelf endovascular stent-grafts and included aortic neck diameter>32mm, neck length <10mm, greater than 60 degrees of neck angulation, iliac vessels <6.5mmin diameter or significant tortuosity and inappropriate landing zones with extreme calcification, thrombus or conical shape.

GAS

The updated preoperative GAS for each patient presenting with rAAA was calculated according to the following formula: risk score = age in years +17 points for hemodynamic instability +7 points for CAD +10 points for history of stroke +14 points for CRF+7 points for open surgery (5).

Rupture after EVAR

For patients presenting with rupture after EVAR, a complimentary data extraction was performed, including i) information of previous EVAR; type of endograft used (commercial type), follow-up protocol, ii) data concerning the operation performed for the rAAA (if EVAR: type of endograft used, type of endoleak, migration, infection of endograft, free or covered rupture, use of aortic collar/limb extensions; if open repair: type of cross-clamping).

Statistical analysis

Continuous variables were expressed as mean ± SE. Standard statistical procedures (nonparametric chi-square distribution, Fischer's exact test and t-test with corresponding p values) were used as appropriate. Univariate logistic regression analysis was used to identify independent risk factors for in-hospital mortality. Multivariate logistic regression analysis was also performed with in-hospital mortality as dependent and statistically significant variables in univariate analysis as confounders. In-hospital case fatality rates (CFR) were appropriately calculated for EVAR and OSR as the ratio of deaths within the designated population of respective cases. The receiver-operator characteristic (ROC) curve was used to determine the value of the GAS in predicting in-hospital death. The *Cuzik test for trend* was used to evaluate trends of proportion (%) of EVAR for rupture and rupture after EVAR over time. Furthermore, number needed to treat (NNT) for EVAR was calculated as the inverse of the absolute risk reduction. Linear regression analyses with annual change of proportion (%) of EVAR for rupture and rupture after EVAR as the dependent variable was also conducted. To test whether correlation between proportion (%) of EVAR for rupture and rupture after EVAR existed, Spearman correlation coefficient (rho) was used. All p-values ≤ 0.05 were considered statistically significant. Stata statistical software (version 12.0, Stata Corp) was used for the analysis.

Results

During the study period, a total of 418 patients (92.3% males, mean age=74.3±8.8 years) presented with rAAA. Among them, 113 patients (27.0%) underwent EVAR. Baseline characteristics did not differ between the two categories (EVAR vs. OSR, Table 1). Hemodynamic instability was more frequent among patient operated with open repair (p=0.004). A total of 189 patients died after the operation (45.2%). Mortality after EVAR was 20.4% versus 54.4% after open repair (p<0.001). NNT for EVAR after rupture was equal to 3 (NNT=3, 95%CI=2.3-4.0), meaning that about one in every three patients will benefit from endovascular approach, concerning mortality. Univariate analysis evidenced that age≥80 years (OR=2.08, 95%CI=1.37-3.17), CAD (OR=2.02, 95%CI=1.35-3.03), CRF (OR=2.38, 95%CI=1.22-4.62), hemodynamic instability (OR=6.33, 95%CI=4.12-9.71) and open repair (OR=4.67, 95%CI=2.81-7.79) increased the risk for in-hospital mortality (Table 2). Of note, in multivariate analysis, all of the independent risk factors remained statistically significant (Table 3).

The mean GAS was statistically different among patients treated with EVAR (0.64, 95%CI=0.51-0.77) and OSR (0.80, 95%CI=0.75-0.85); p value=0.03, Table 1. GAS among patients who died was 99.7±1.01 compared with 85.2±0.81 among survivors (p<0.001). The mean GAS among patients who died was 92.7±3.36 for patients treated with endovascular repair and 100.7±1.03 for patients treated with open surgery (p=0.01).The AUC was used to summarize the inherent capacity of GAS to discriminate dead from alive patients, indicating the probability that GAS ranked a randomly chosen dead patient higher than a randomly chosen alive one; AUCs ~0.5 indicated poor test

performance, while AUCs~1 the perfect one.The AUC for the GAS among all patients with rAAA was 0.78 (95%CI=0.74-0.83, p<0.001), with the best cut-off value=89 (sensitivity=80.4%, specificity=61.1%). With respect to the operation performed for the AAA rupture, AUC was 0.80 (95%CI=0.75-0.85, p<0.001) for open repair and 0.64 (95%CI=0.51-0.77, p<0.04) for EVAR and the difference was statistically significant (p=0.03, Table 1,Figure 1).

History of previous AAA operation was recorded in 25 patients (6%); 92% males, mean age=76.5±1.9 years. Among them, 22 patients (88%) had been operated with endovascular approach (Table 4). In-hospital CFR was 36.4% for the 22 patients with previous EVAR, contrary to 66.7% for the three patients with previous open repair (Fischer's exact test; p=0.54). Regression analysis for 22 patients with rupture after EVAR evidenced that open repair was the only independent risk factor for in-hospital death (OR=17.50, 95%CI=1.60-191.89). GAS for these patients was 93.3±4.1 and AUC was 0.55 (95%CI=0.27-0.84, p=0.7). Time of rupture was 4.1±0.6 years after the initial EVAR. Among patients with rAAA, Endurant / Talent endografts (Medtronic, Inc.) had been used for the initial repair in 14 patients (63.6), whereas only 7 patients (31.8%) reported a regular follow-up protocol. The majority of endoleaks were type Ia (72.7%), whereas migration was discovered in 11 of these patients. Free rupture in abdominal cavity was found in 6 cases (27.3%). Among the 11 patients treated with EVAR for rupture, Endurant / Talent endografts (Medtronic, Inc.) was used in 9 cases (81.8%). In 11 patients who were operated by open approach, suprarenal or supraceliac cross-clamping was necessary in 54.6% of the cases.

Proportion of EVAR for rAAAs evidenced a gradual increase from 6.3% in 2006 to 40.9% in 2012 (p for trend=0.03, Figure 2). Similarly and interestingly, ruptures after EVAR showed an increase from 1.3% in 2007 to 18.2% in 2012 among all ruptures (p for trend=0.03). Annual change for proportion of EVAR for rupture was 5% (b=5.00, p=0.004) and for rupture after EVAR was 2.5% (b=2.54, p=0.005).A correlation between proportion of EVAR for rupture and rupture after EVAR was also recorded (rho=0.89, $p<0.01$).

Discussion

The results of the current multicentre study, including 418 patients presenting with rAAA in seven Vascular Departments over a 6-year period in Greece evidenced that older age, CAD, CRF and hemodynamic instability were independent risk factors for in-hospital mortality. Open repair was also presented with a more than 5-times fold increased risk for death. Interestingly, it was estimated that for every three patients being treated with endovascular approach, one death from rAAA was being avoided. Among the 22 patients presenting with rupture after previous EVAR, mortality was significantly reduced when operated with EVAR compared to open repair. GAS risk-scoring method has proven to be highly predictive of in-hospital death for patients presenting with rAAA. However, it evidenced a less valuable effect for patients operated with EVAR and no effect in patients with rAAA after EVAR. Of note, a gradual increase in the proportion of EVAR for rupture was noticed, with 5% annual change and a gradual increase with 2.5% annual change was recorded for rupture after EVAR; interestingly, these trends were highly correlated.

Determinants of in-hospital mortality after rAAA have been evaluated in the past decade in an effort to identify modifiable risk factors. In the "Vascunet Report", comprising of 7,040 rAAAs from vascular registries of Australia, Denmark, Finland, Hungary, Italy, Norway, Sweden, Switzerland and UK during the period 2005-2009, increasing age, open repair and presence of comorbidities were associated with in-hospital mortality (6). In line with the above, our study has evidenced differences in mortality with respect to the type operation, instability, age, CAD and CRF. Among these factors, EVAR evidenced a

protective effect, suggesting that three patients need to be treated with an endograft to prevent one death if open surgery was the only option. Although single risk factors may play important role in the every-day practice, a cumulative operative risk may be more useful, especially in high-risk patients (7). Towards this direction, individual risk stratification has taken on an important role in clinical decision-making during the last years. Evaluated on population-based nationwide registries, the GAS was proved to be predictive of postoperative mortality (5). Our study has confirmed that updated GAS, as opposed by Visser et.al. (5), may be used as a useful tool of risk stratification in patients with rAAA who were operated with open approach (AUC=0.80, $p<0.001$). However, in subgroup analyses, GAS showed borderline discriminative ability in patients operated with EVAR (AUC=0.64, $p=0.04$) and no discriminative ability in patients with rupture after EVAR and operated with either open or endovascular technique (AUC=0.55, $p=0.7$). This may rise the question whether other factors will accurately predict mortality after endovascular approach and thus GAS should be further and appropriately modified in these patients.

It is still open to debate whether patients with ruptured AAA will benefit from endovascular approach, compared to open surgery, in terms of mortality (2). Most methodological issues include difficulty to perform truly randomized studies and as a result, inadequate control of potential confounding secondary to inadequate patient matching make results more inconsistent. In a meta-analysis by Rayt et.al.(1), the pooled mortality rate from EVAR after rAAA across 31 studies concerning 982 patients was 24%, whereas in a meta-analysis by Hoornweg et al.(8), the reported overall early mortality rate of 60,822 patients undergoing open ruptured aneurysm repair was 48.5%.

Our results go along with the recent meta-analyses' reports and evidenced significant differences in mortality after EVAR (20.4%), compared to open procedure (54.4%), even after adjustment for significant risk factors, including hemodynamic instability. Despite the fact that these results look promising in favor of EVAR, a small randomized study (9) evidenced much higher and similar mortality rates between open and endovascular repair of rAAA (53% in both groups). This discrepancy may be partially due to subjective selection bias of treating surgeon and anatomical suitability for EVAR. However, a recent study (10) evidenced that the reported reduction in mortality between EVAR and open repair is unlikely to occur due to selection bias based on anatomical AAA configuration. Furthermore, comparison of treatment effects from observational studies presented similar results compared with well-conducted randomized controlled trials(11). It is therefore assumed that observational studies comparing EVAR and open repair for rAAA may provide with valid estimation of the treatment effects.

Although EVAR for ruptured AAAs has been well studied in the literature, rupture after EVAR has received less attention, probably because such cases represent a rare event and patients will not always present their AAA rupture in the same institution (12). Concerning time of rupture, most cases presented within the first 2-3 years of EVAR,as also indicated in our study (12). Endoleaks type I and III and device migration were found to be significantly associated with rupture risk after EVAR, as reported by EUROSTAR investigators (13, 14). In our cohort, almost 73% and 14% of the patients presented with type Ia and Ib endoleaks, respectively. In a systematic review, summarizing a large cohort of patients with rAAA after EVAR, mortality was 26.9% for 26 patients who were treated with endovascular technique and 50% for the 138 patients who received open repair. Our

study demonstrated comparable results; in-hospital CFR was 36.4% for the 22 patients with previous EVAR, contrary to 66.7% for the three patients with previous open repair, although the sample was smaller. Of note, no or unknown follow-up was recorded in 68% of our patients. It seems that appropriate surveillance protocol on the first 2-3 years after EVAR may possibly reduce theAAA rupture rate, as also proposed by systematic reviews (12) and observational studies (15). In a study (16) analyzing the results of EVAR trials 1 and 2, 27 ruptures after EVAR were identified. Although not statistically significant, "Medronic Talent" endograft presented with higher rupture rates among the graft manufacturers; in our patients' sample Endurant / Talent (Medtronic, Inc.) was more frequently used as the initial endograft among patients with ruptures after EVAR.

Our data reflected an increasing role of endovascular repair for ruptured AAAs. We identified a 5% annual increase in use of EVAR for rupture. Similarly, data from Nationwide Inpatient Sample (NIS), the largest inpatient, all-payer database in the United States (US), evidenced that use of EVAR increased significantly from 6% of all emergency repairs in 2001 to 11% in 2004 ($p<0.01$) (17). This may be attributed to the fact that this technique may reduce blood loss, length of stay in the intensive care unit and mortality in selected patients (17). Similarly, a concomitant 2.5% annual increase in ruptures after EVAR was also noticed, whereas a highly correlated relation was evident between the two proportions. In line with our findings, the EUROSTAR registry data evidenced that the annual, cumulative AAA rupture risk after EVAR was approximately 2% at six years (18). It seems thus, that EVAR for rupture and rupture after EVAR may indicate an interactive pattern. A potential reason might be a trend for "outside instructions for use; IFU" implantation of endografts, reflecting the cumulative experience

and improvements in learning curve of the vascular surgeons and advances in stent graft technology and manufacturing.

The current study reflects a review of a large prospectively collected administrative database. However, limitations may exist and include potential selection of patients for endovascular repair constituting a hemodynamically lower-risk category selection of patients for EVAR with a more suitable anatomic configuration (19). Furthermore, hospital and surgeon-specific procedure volumes may have influenced patient selection, concerning the type of operation for rAAA. Therefore, randomized controlled trials, although difficult to perform in an acute severe condition like rAAA, are needed (20).

Conclusion

EVAR may be associated with reduced in-hospital mortality compared to OSR in patients with rAAA. Although GAS has evidenced great discriminative ability in patients operated with open surgery, an update might be needed for patients treated with EVAR and patients with rupture after EVAR. A gradual increase in the use of EVAR for ruptured aneurysms was found, as well as a parallel increase in the proportion of patients presenting with rAAA after EVAR.

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Table 1. Descriptive characteristics of 418 patients presenting with rAAA with respect to the operation performed

	EVAR (n=113)	OSR (n=305)	
Variable	n (%)	n (%)	p value
Male Gender	107 (94.7)	279 (91.5)	n.s
Age ≥80 years	43 (38.1)	87 (28.5)	n.s
Current Smoker	83 (73.5)	196 (64.3)	n.s
DM	26 (23.0)	95 (31.1)	n.s
Hypetension	85 (75.2)	250 (82.0)	n.s
CAD	38 (33.6)	113 (37.0)	n.s
Stroke	11 (9.7)	31 (10.2)	n.s
CRF	12 (10.6)	30 (9.8)	n.s
Reoperation in abdominal aorta	11 (9.7)	14 (4.6)	n.s
Hemodynamic Instability	36 (31.9)	145 (47.5)	0.004
In-hospital Death	23 (20.4)	166 (54.4)	<0.001
GAS (mean±SE)	86.0±1.30	93.9±0.84	<0.001
AUC (95%CI)	0.64 (0.51-0.77)	0.80 (0.75-0.85)	0.03

Abbreviations: rAAA: ruptured abdominal aortic aneurysm, EVAR: endovascular aortic repair, OSR: open surgical repair, DM: diabetes mellitus, CAD: coronary artery disease, CRF: chronic renal failure, GAS: Glasgow Aneurysm Score, AUC: area under the curve, CI: Confidence Interval, n.s: not significant

Table 2. In-Hospital Mortality and Results of Univariate Logistic Regression Analysis for 418 patients with rAAA (OR, 95% CIs)

Variable	Category	Patients (n)	In-hospital mortality (n)	Crude OR (95%CI)
Gender	female	32	15	Reference
	male	386	174	0.93 (0.45-1.92)
Age (years)	<80	288	114	Reference
	≥80	130	75	**2.08 (1.37-3.17)**
Current Smoker	No	153	77	Reference
	Yes	279	120	0.77 (0.51-1.15)
DM	No	297	127	Reference
	Yes	121	62	1.41 (0.92-2.15)
Hypertension	No	83	34	Reference
	Yes	335	155	1.24 (0.76-2.02)
CAD	No	267	104	Reference
	Yes	151	85	**2.02 (1.35-3.03)**
History of Stroke	No	376	169	Reference
	Yes	42	20	1.11 (0.59-2.11)
CRF	No	376	162	Reference
	Yes	42	27	**2.38 (1.22-4.62)**
Reoperation	No	393	179	Reference
	Yes	25	10	0.80 (0.35-1.82)
Hemodynamic Instability	No	237	63	Reference
	Yes	181	126	**6.33 (4.12-9.71)**
Type of operation	EVAR	113	23	Reference
	Open	305	166	**4.67 (2.81-7.79)**

Abbreviations: DM: diabetes mellitus, CAD: cardiac artery disease, CRF: chronic renal failure, EVAR: endovascular aortic repair, OR: Odds Ratio, CI: Confidence Interval

Table 3. Multivariate Logistic Regression Model for 418 patients with rAAA: Prediction of In-Hospital Mortality

Variable	Adjusted OR (95%CI)
Age ≥80 years	2.67 (1.58-4.51)
CAD	2.83 (1.71-4.67)
CRF	2.62 (1.17-5.91)
Hemodynamic Instability	7.77 (4.74-12.74)
Open Repair	5.47 (3.03-9.85)

Abbreviations: CAD: cardiac artery disease, CRF: chronic renal failure, OR: Odds Ratio, CI: Confidence Interval, rAAA: ruptured abdominal aortic aneurysm

Table 4. Characteristics of 22 patients presenting with rAAA after EVAR

	n	%
Patient's Charavteristics (n=22)		
Male Gender	21	95.5
Age ≥80 years	12	54.5
Current Smoker	12	54.5
DM	7	31.8
Hypetension	16	72.7
CAD	6	27.3
History of Stroke	3	13.6
CRF	2	9.1
Hemodynamic Instability	10	45.5
In-hospital Death	8	36.4
Characteristics of EVAR before rupture (n=22)		
Typeofendograft		
Medronic (Endurant, Talent)	14	63.6
Endologix (Powerlink)	2	9.1
Vascutek (Anaconda)	1	4.5
Gore (Excluder)	1	4.5
Edwards (LifePath)	1	4.5
Cardiatis (Multilayer)	1	4.5
Unkown	2	9.1
Follow-up		
Yes	7	31.8
No/Unknown	15	68.2
Characteristics of AAA rupture (n=22)		
Type of endoleak		
Ia	16	72.7
Ib	3	13.6
II	1	4.5
III	1	4.5
IV	1	4.5
Endofraft migration	11	50
Endofraft infection	1	4.5
Free rupture	6	27.3
EVAR after rupture (n=11)		
Type of endograft used		
Medronic (Endurant, Talent)	9	81.8
Gore (Excluder)	2	18.2
Use of aortic collar for Ia endoleak (n=6)	6	100
Use of limb extentions for Ib and III endoleak (n=4)	4	100
OSR after rupture (n=11)		
Type of clamping		
Infrarenal	5	45.5
Suprarenal	3	27.3
Supraceliac	3	27.3

Abbreviations: rAAA: ruptured abdominal aortic aneurysm, EVAR: endovascular aortic repair, DM: diabetes mellitus, CAD: coronary artery disease, CRF: chronic renal failure

Figure 1. Results of the ROC curve analysis predicting in-hospital death for patients operated with EVAR and Open repair.

Abbreviations: ROC: receiver–operator characteristic, EVAR: Endovascular aortic repair

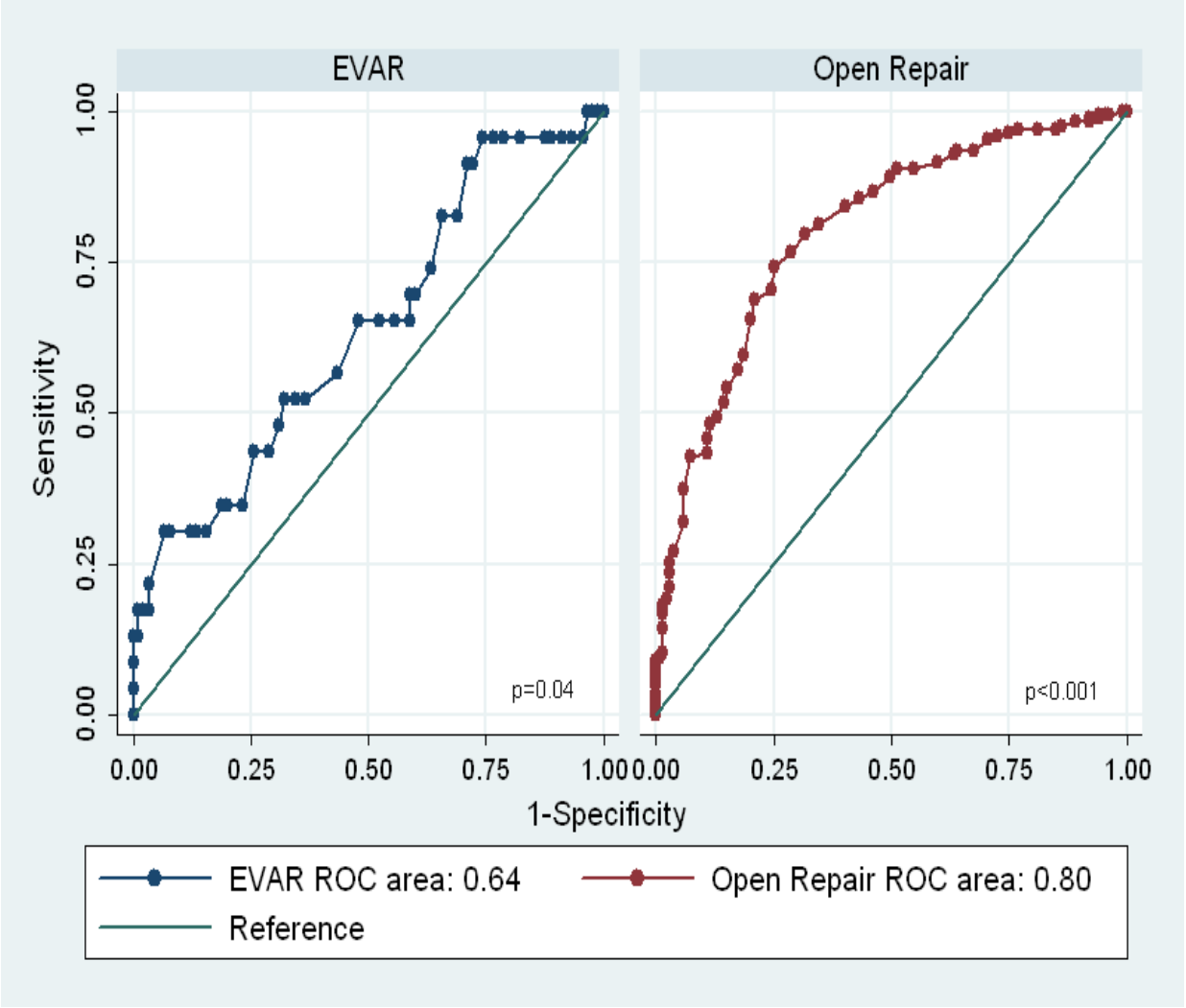

Figure 2. Time Trends of proportion (%) of EVAR for rAAA and rAAA after EVAR.

Abbreviations: EVAR: Endovascular aortic repair, rAAA: ruptured abdominal aortic aneurysm.