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REPORTS OF ORIGINAL INVESTIGATIONS

Endovascular versus open approach to aortic aneurysm repair surgery: rates of postoperative delirium

Voie d'abord endovasculaire contre voie d'abord ouverte pour la chirurgie de l'anévrysme de l'aorte: incidence de delirium postopératoire

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Abstract

Purpose *Our objective was to compare open and endovascular aortic aneurysm repair with respect to postoperative delirium.*

Methods *After Institutional Ethics Review Board approval, we conducted a retrospective review of all patients who underwent abdominal and thoraco-abdominal aortic aneurysm repair surgery at Toronto General Hospital during June 2006 to December 2007. Patients were classed into either the OPEN or the endovascular (EVAR) group based on the type of surgery and were assessed for the presence of delirium after surgery. The NEECHAM Confusion Scale and the validated chart review instrument were used for diagnosis of delirium. Patients with dementia and/or abnormal levels of consciousness preoperatively were excluded.*

Results *There were 256 patients included in the study, 149 (58%) in the OPEN group and 107 (42%) in the EVAR group. Patients in the EVAR group were considerably older, 74 (10) yr vs 68 (9) yr, and they had shorter duration of surgery, 150 [119, 180] min vs 200 [165, 260] min, respectively, $P < 0.0001$. Postoperative delirium was present in 43 (29%) patients in the OPEN group and 14 (13%) patients in the EVAR group (95% confidence interval [CI], 22 to 36 vs 95% CI, 7 to 19, respectively; $P = 0.003$). Hospital length of stay was 8.3 [6.6, 13.4] days in the OPEN group and 4.5 [3.1, 6.4] days in the EVAR group, $P < 0.0001$.*

Conclusions *Perioperative management of patients undergoing endovascular aortic aneurysm repair was associated with lower rates of delirium after surgery than that of patients undergoing open aortic aneurysm repair.*

Résumé

Objectif *Notre objectif était de comparer la chirurgie de l'anévrysme de l'aorte par voie ouverte ou endovasculaire en termes de delirium postopératoire.*

Méthodes *Après avoir obtenu l'accord du comité d'éthique de la recherche de l'établissement, nous avons effectué une analyse rétrospective de tous les patients ayant subi une réparation chirurgicale d'un anévrysme de l'aorte thoraco-abdominale et abdominale à l'hôpital général de Toronto entre juin 2006 et décembre 2007. Les patients ont été classés dans un groupe OUVERT (OPEN) ou dans le groupe endovasculaire (EVAR) selon le type de chirurgie; la survenue d'un delirium postopératoire a été recherchée. L'échelle de confusion de NEECHAM et l'instrument validé d'analyse des dossiers ont été utilisés*

Author contributions *Scott Beattie and George Djaiani* contributed to the conception of the study. *Rita Katznelson, Scott Beattie, Jo Carroll, Thomas Lindsay, and George Djaiani* contributed to the study design. *Scott Beattie* took an active part in setting up the inclusion and exclusion criteria. *George Djaiani* supervised the acquisition, analysis, and interpretation of data. *Konrad Salata* participated in the analysis of data and drafted the first version of the manuscript. *Konrad Salata, Rita Katznelson, and Thomas Lindsay* were involved in the interpretation of the data.

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pour le diagnostic de delirium. Les patients qui avaient une démence et/ou un niveau de conscience anormal en préopératoire ont été exclus.

Résultats *Au total, 256 patients ont été inclus dans l'étude: 149 (58 %) dans le groupe OUVERT et 107 (42 %) dans le groupe EVAR. Les patients du groupe EVAR étaient considérablement plus âgés: 74 (10) ans contre 68 (9) ans; et ils ont eu une chirurgie plus courte (respectivement, 150 [119 à 180] minutes contre 200 [165 à 260], P < 0,0001). Un delirium postopératoire a été retrouvé chez 43 (29 %) patients du groupe OUVERT et chez 14 (13 %) patients du groupe EVAR (intervalles de confiance [IC] à 95 % respectifs: 22 à 36 contre 7 à 19; P < 0,003). La durée de l'hospitalisation a été de 8,3 (6,6 à 13,4) jours dans le groupe OUVERT et de 4,5 (3,1 à 6,4) jours dans le groupe EVAR (P < 0,0001).*

Conclusions *La prise en charge périopératoire des patients subissant une réparation chirurgicale endovasculaire d'un anévrysme aortique a été associée à une incidence moindre de delirium par rapport aux patients subissant une chirurgie ouverte pour anévrysme aortique.*

Both OPEN and endovascular (EVAR) approaches are well-recognized treatment modalities for abdominal (AAA) and thoraco-abdominal (TAA) aortic aneurysm repair surgery. Delirium is a serious postoperative complication associated with higher postoperative morbidity and mortality, prolonged intensive care unit and hospital length of stay (LOS), as well as increased healthcare costs.[1-3] Recently, we reported that older age, history of cerebrovascular accident or transient ischemic attack, depression, preoperative beta-blocker administration, and open aortic reconstruction procedures were associated with a higher risk of postoperative delirium.[4] Rates of delirium after major vascular surgery vary from 30% to more than 50%.[5-8]

In this study, we compared the incidence of postoperative delirium in patients undergoing OPEN aortic aneurysm repair surgery with the incidence in patients undergoing the EVAR approach. We hypothesized that the EVAR approach would be associated with a reduced incidence of postoperative delirium.

Methods

After Institutional Ethics Review Board approval, we conducted a retrospective review of all patients who underwent AAA and TAA repair surgery at Toronto General Hospital throughout June 2006 to December 2007. We used the same database for the current study as for our previous publication[4]; however, we extended the current study to an 18-month observation period, thereby increasing the sample size of patients undergoing AAA and TAA procedures. Both elective and emergency cases were eligible for the study. The surgical team determined the type of procedure (EVAR or OPEN) according to the vascular anatomy. Patient demographic characteristics and the presence of comorbidities were recorded, including but not limited to hypertension, coronary artery disease, and diabetes mellitus. We also recorded the concurrent medications as derived from the individual patient medical records.

An abnormal level of consciousness prior to surgery was defined as delirium, dementia, confusion, and/or lack of response to verbal stimulation. This information was acquired from chart review. The NEECHAM Scale was divided into three parts to reflect the level of information processing, behaviour, and basic physiological variables (Table 1). Patients with scores of 20-24 on the Scale were classed as "mild confusion", and those with scores < 20 were classed as "moderate to severe confusion". Patients were excluded from the analysis if their preoperative NEECHAM Confusion Scale[9] score was < 25 or if they had a history of dementia and/or an abnormal level of consciousness prior to surgery. The NEECHAM Scale was administered by bedside nurses who were skilled and in-service trained to record these data, a standard practice in our institution for many years. The chart review was performed by two of the investigators following patient discharge. The investigators sought evidence of fluctuations in mental status, and they looked for key words in the patient progress notes, such as agitation, disorientation, and confusion.

Patients were classed into the OPEN or the EVAR group based on the type of surgery. After surgery, they were assessed for the presence of delirium once daily or more often if indicated throughout their hospital stay. Identification of delirium was based on the assessments of the NEECHAM scores and the validated chart review instruments, as

Table 1 NEECHAM Confusion Scale[9]

	Score
Level 1: Processing	
Attention/alertness/responsiveness	0-4
Command (recognition)	0-5
Orientation/memory/speech	0-5
Level 2: Behaviour	
Appearance/Hygiene	0-2
Motor	0-4
Verbal	0-4
Level 3: Physiologic Control	
Vital Function Stability	0-2
Oxygen Saturation Stability	0-2
Urinary Continence Control	0-2
Total Score	0-30

described previously.[4] Patients with NEECHAM scores < 25 and/or positive results from a validated chart review were considered to have delirium. Delirium rates were compared in all ages as well as in the subgroups of over 75 yr and under 75 yr. The onset and duration of delirium were also measured. Anesthetic management followed standard institutional practice and the surgical techniques (both OPEN and EVAR) followed routine clinical care at Toronto General Hospital. All patients were transferred to the cardiovascular intensive care unit after surgery. The sample size was based on the number of patients available in the database during the reported study period.

Statistical analysis

Descriptive analysis was performed for all variables measured pre- and postoperatively. Parametric testing was done with the Student's *t* test for parametric data, and the Mann-Whitney U test was applied for non-parametric testing. The Chi square test or Fisher's exact test was used for categorical variables. Univariate logistic regression analysis was performed to explore the relationship between the type of procedure and preoperative risk factors. Multivariable logistic regression was used to examine the relationship between delirium and potential pre- and postoperative risk factors. The predictors were selected using a stepwise selection. A significance level of 0.4 was selected to allow a variable into the model, and a significance level of 0.2 was used for a variable to remain in the model. The number of covariates was constrained to be equal to one-tenth of the number of patients in the population. The overall performance and fitting of the model were evaluated at every step. Finally, the predictors with a P value < 0.2 remained in the model. The Hosmer-Lemeshow goodness-of-fit test was applied for the final selected model, and its discriminative power was assessed using the concordance index.

The interaction effect of the procedure type and the predictors was also examined by including the main effects and their interaction terms. For those variables that remained in the final model, the interaction terms were also examined by including all the other main effects plus one interaction term at each measure. For the multivariable logistic regression, the coefficient estimates, the odds ratios, and the 95% confidence intervals (CI) were calculated. A P value of 0.05 was considered statistically significant. All analyses were performed using SAS® version 9.3 (SAS Institute, Inc, Cary, NC, USA).

Results

Fourteen patients were excluded from the study, and 57 (22%) of the 256 patients entered into the database developed delirium after surgery. Delirium was present in 43 (29%) patients in the OPEN group and 14 (13%) patients in the EVAR group (95% CI, 22 to 36 *vs* 95% CI, 7 to 19, respectively; $P = 0.003$). Patients in the EVAR group were considerably older, and their surgery was shorter in duration. (Table 2) Although delirium rates were higher in patients > 75 yr of age, the relationship between the two groups was sustained (Figure). There were no significant differences between the two groups with regard to the onset and duration of delirium (Table 3). Postoperative morbidity and mortality were similar between the two groups; however, the hospital LOS was significantly longer in the OPEN group (Table 4). Multivariable logistic regression identified that age and type of procedure (OPEN *vs* EVAR) were independent predictors of postoperative delirium (Table 5). For the final model, the Hosmer–Lemeshow test indicated good calibration (Chi square = 3.09; P value = 0.93), and the concordance index statistic is 0.76.

Discussion

Although patients who underwent EVAR procedures were significantly older, the current report shows that they had lower rates of postoperative delirium and shorter hospital lengths of stay compared with patients who underwent the OPEN approach for aortic aneurysm repair surgery. Current data are limited regarding a direct association between EVAR and postoperative delirium. A recent survey by Koebrugge *et al.*[10] of 107 patients showed that the prevalence of delirium in patients undergoing OPEN and EVAR procedures was 31% and 6%, respectively. Furthermore, the authors showed that age and emergency surgery were significant predictors of postoperative delirium. The current study echoed their report with respect to delirium rates after OPEN procedures; however, the EVAR group had twice as many delirious patients than the previous study. This discrepancy was likely attributable to an almost three-fold increase in the number of emergency cases in the current cohort of EVAR patients.

The EVAR approach to aortic aneurysm repair is now clinically well established. Historically, the EVAR-1 trial showed that EVAR was associated with a lower 30-day postoperative mortality compared with the OPEN approach.[11] However, the mortality was similar between the two groups at the four-year follow-up. In fact, at four years, EVAR was associated with higher re-intervention rates and no benefits to health-related quality of life.[12] These findings are consistent with the more recent report on a six-year follow-up of patients undergoing either EVAR or OPEN repair of AAA.[13] At the same time, interestingly, the number of EVAR procedures has increased, particularly in octogenarians.[14]

Although the etiology of delirium is multifactorial, the reasons behind the higher prevalence of delirium in the OPEN

Table 2 Demographic data and surgical characteristics

	OPEN Group ($n = 149$)	EVAR Group ($n = 107$)	P value
Demographics			
Age (yr)	68 (9)	74 (10)	< 0.0001
Male	121 (81%)	86 (80%)	0.89
ASA class	4 (2-5)	4 (2-5)	0.96
Preoperative Morbidity n (%)			
Hypertension	120 (80)	87 (81)	0.87
Diabetes Mellitus	35 (24)	24 (22)	0.84
CAD	65 (44)	49 (46)	0.73
Myocardial Infarction	31 (21)	22 (20)	0.96
CVA/TIA	17 (11)	21 (19)	0.07
Depression	9 (6)	12 (11)	0.14
PVD	29 (19)	7 (7)	0.003
ACE inhibitors	53 (36)	36 (34)	0.75
Statins	88 (59)	53 (50)	0.13
β-blockers	15 (10)	7 (7)	0.32
Creatinine preoperative ($g \cdot L^{-1}$)	105 [35, 610]	105 [47, 616]	0.63
Hb preoperative ($g \cdot L^{-1}$)	134 [70, 189]	134 [81, 185]	0.88
Surgery			
Abdominal/Thoraco-abdominal	138/11	87/20	0.006
Emergency	36 (24%)	17 (16%)	0.11
Duration (min)	200 [165, 260]	150 [119, 180]	< 0.0001

Data are expressed as mean (standard deviation), number of patients (%), median (range), or median [IQR].
ACE = angiotensin-converting enzyme; ASA = American Society of Anesthesiologists; CAD = coronary artery disease; CVA/TIA = cerebrovascular accident / transient ischemic attack; EVAR = endovascular; PVD = peripheral vascular disease; ACE = angiotensin-converting-enzyme; Hb = hemoglobin

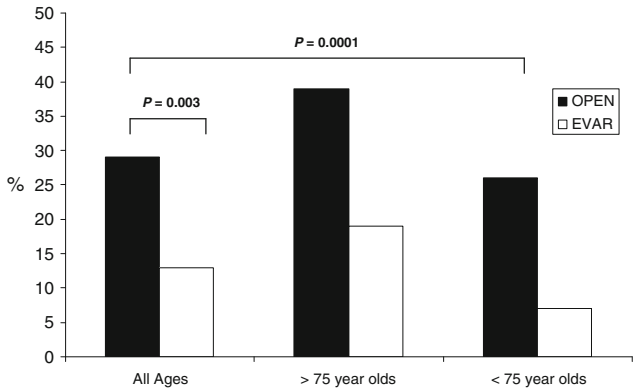

Figure Postoperative delirium rates in the OPEN compared with the endovascular (EVAR) group: age effects. There was a significant difference between the OPEN and EVAR groups in all ages, $P = 0.003$. In under 75 year olds the postoperative delirium was present in 29 (26%, 95% confidence interval [CI], 18 to 34), and 4 (7%, 95% CI, 5 to 13) patients. In over 75 year olds the postoperative delirium was present in 14 (39%, 95% CI, 23 to 54), and 10 (19%, 95% CI, 18 to 21) patients

group were likely related to the extent of surgical trauma, consequent systemic inflammatory response, and oxidative stress associated with more invasive procedures. An intriguing hypothesis that unifies potential causes and risk factors of postoperative delirium involves changes in central γ-aminobutyric acid (GABA)-ergic transmission.[15] In brief, the development of postoperative delirium may depend on the degree of neuronal connectivity within the brain that can modify GABA-ergic tone. This phenomenon is determined by *non-modifiable* risk factors, such as age or preexisting cognitive impairment, and *modifiable* risk factors, such as inflammation, psychotropic drug use, and metabolic abnormalities. In light of this hypothesis, postoperative delirium may develop secondary to the extent of surgical trauma. Consequently, patients undergoing more invasive surgeries, such as cardiac and orthopedic surgery, as well as the OPEN approach to aortic aneurysm repair surgery may have higher rates of postoperative delirium. This hypothesis provides a unified starting point for initiating further research studies delineating the exact pathophysiologic mechanisms involved in the development of postoperative delirium.

There are several limitations to the current study. The current study could not imply any causality between the type of surgery and postoperative delirium. Future trials should be able to confirm or refute this association. Furthermore, there are many known perioperative risk factors for delirium that were not included in the current analysis. For example, postoperative analgesia, duration of anesthesia, and blood product transfusion could have potentially influenced the rates of postoperative delirium. Consequently, rather than looking at the individual risk factors, we chose to compare the two different approaches with perioperative care of patients undergoing aortic aneurysm repair surgery. The general applicability of our

Table 3 Characteristics of delirium assessment

	OPEN Group ($n = 149$)	EVAR Group ($n = 107$)	P value
NEECHAM scores	27 [23, 30]	29 [27, 30]	0.01
	Patients with postoperative delirium		
	OPEN Group ($n = 43$)	EVAR Group ($n = 14$)	
NEECHAM scores	17 [15, 21]	17.5 [15, 20.5]	0.78
Onset of Delirium (days)	3 [1, 4]	2 [2, 11]	0.18
Duration of Delirium (days)	3 [2, 5]	2 [2, 11]	0.53
Assessments per patient	6 [4, 9]	3 [2, 5]	0.0001

Data expressed as median [interquartile range]. EVAR = endovascular

Table 4 Postoperative morbidity, mortality, and hospital length of stay

	OPEN ($n = 149$)	EVAR ($n = 107$)	P value
Postoperative morbidity			
Myocardial Infarction	7 (4.7)	4 (3.7)	0.70
Stroke	4 (2.7)	3 (2.8)	0.95
Creatinine > 150 $\mu mol \cdot L^{-1}$	20 (13.4)	15 (14.0)	0.89
Death	5 (3.3)	4 (3.7)	0.87
Hospital length of stay	8.3 [6.6, 13.4]	4.5 [3.1, 6.4]	< 0.0001

Data expressed as number of patients (%), and days [IQR]. EVAR = endovascular

Table 5 Independent predictors of postoperative delirium

Variable	Coefficient Estimate	OR	95% CI	P Value
Procedure (OPEN *vs* EVAR)	−0.5512	0.332	(0.155 to 0.713)	0.005
Case type (Elective *vs* emergency)	−2.9167	0.551	(0.240 to 1.263)	0.17
Duration of Surgery	0.00396	1.004	(1.000 to 1.008)	0.06
Age	0.0402	1.041	(1.002 to 1.082)	0.04
Preoperative Hb ($g \cdot L^{-1}$)	−0.0162	0.984	(0.966 to 1.002)	0.08
ASA (2/3 *vs* 4/5)	−0.3722	0.475	(0.221 to 1.019)	0.06

For the final model, the Hosmer–Lemeshow test indicated good calibration (Chi square = 3.09; P value = 0.93), and the concordance index statistic is 0.76. OR = odds ratio; CI = confidence interval; EVAR = endovascular; Hb = hemoglobin; ASA = American Society of Anesthesiologists

results may be influenced by the different perioperative management strategies at different institutions.

In summary, in the current study, we identified an association between the perioperative management of patients undergoing endovascular aortic aneurysm repair and lower delirium rates after surgery.

Competing interests None declared.

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