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SCIENTIFIC ARTICLE

Carotid endarterectomy: review of 10 years of practice of general and locoregional anesthesia in a tertiary care hospital in Portugal

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KEYWORDS
Carotid endarterectomy;
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Review

Abstract
Background: Retrospective and prospective randomized studies have compared general and locoregional anesthesia for carotid endarterectomy, but without definitive results.
Objectives: Evaluate the incidence of complications (medical, surgical, neurological, and hospital mortality) in a tertiary center in Portugal and review the literature.
Methods: Retrospective analysis of patients undergoing endarterectomy between 2000 and 2011, using a software for hospital consultation.
Results: A total of 750 patients were identified, and locoregional anesthesia had to be converted to general anesthesia in 13 patients. Thus, a total of 737 patients were included in this analysis: 74% underwent locoregional anesthesia and 26% underwent general anesthesia. There was no statistically significant difference between the two groups regarding per operative variables. The use of shunt was more common in patients undergoing general anesthesia, a statistically significant difference. The difference between groups of strokes and mortality was not statistically significant. The average length of stay was shorter in patients undergoing locoregional anesthesia with a statistically significant difference.
Conclusions: We found that our data are overlaid with the literature data. After reviewing the literature, we found that the number of studies comparing locoregional and general anesthesia and its impact on delirium, cognitive impairment, and decreased quality of life after surgery is still very small and can provide important data to compare the two techniques. Thus, some questions remain open, which indicates the need for randomized studies with larger number of patients and in new centers.

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PALAVRAS-CHAVE
Endarterectomia carotídea;
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Anestesia para cirurgia vascular;
Revisão

Endarterectomia carotídea: revisão de 10 anos de prática de anestesia geral e locorregional num hospital terciário em Portugal

Resumo
Justificativa: Estudos retrospectivos e prospectivos randomizados têm comparado a anestesia locorregional e geral para endarterectomia carotídea, mas sem resultados definitivos.
Objetivos: Avaliar a incidência de complicações (médicas, cirúrgicas, neurológicas e mortalidade intra-hospitalar) num centro terciário em Portugal e revisão da literatura.
Método: Análise retrospectiva dos doentes submetidos a endarterectomia entre 2000 e 2011 com o software consulta hospitalar.
Resultados: Foram identificados 750 doentes, mas em 13 foi necessário converter a anestesia locorregional em anestesia geral. Dos 737 doentes incluídos nesta análise, 74% foram submetidos a anestesia locorregional e 26% a anestesia geral. Não foram encontradas diferenças estatisticamente significativas relativamente às variáveis estudadas no perioperatório entre os dois grupos. O uso de shunt foi mais frequente em doentes submetidos a anestesia geral, diferença estatisticamente significativa. A diferença entre grupos de acidentes vasculares cerebrais e mortalidade não foi estatisticamente significativa. O tempo médio de internamento foi mais curto nos doentes submetidos a anestesia locorregional, diferença estatisticamente significativa.
Conclusões: Verificamos que os dados encontrados são sobreponíveis aos descritos na literatura. Após revisão da literatura constatamos que o número de estudos que comparam anestesia locorregional e anestesia geral e o seu impacto no *delirium*, nas alterações cognitivas e na diminuição da qualidade de vida no pós-operatório é ainda diminuto e pode fornecer dados importantes para a comparação das duas técnicas. Assim, permanecem algumas questões em aberto que obrigam à feitura de estudos randomizados com maior número de doentes e em novas áreas.

Introduction

The indication for carotid endarterectomy (CE) has been demonstrated in randomized controlled trials in symptomatic and asymptomatic patients with stenosis greater than 60% and 70%, respectively.[1,2]

Despite the surgical criteria clarity, there remains little consensus in the evaluation of preoperative risk factors. Factors such as gender, age over 80 years, severe heart or lung disease, kidney disease or kidney failure, symptomatic carotid disease, contralateral occlusion prior to CE, and anatomic reasons are established as risk in some studies,[3–5] which is not shown in other works.[6–8]

The difficulty of identifying the risk factors, associated with decreased mortality,[9] has led to an increased number of patients proposed for this treatment[6,10] and raised questions about the anesthetic approach. Can the anesthetic technique have an impact on clinical outcome?

The GALA study analyzed 3526 patients, compared locoregional anesthesia (LRA) with general anesthesia (GA),[11] and found a trend toward decreased mortality in OR 0.62 (95% CI 0.36–1.07) when using locoregional anesthesia. Subanalysis of this study also showed a reduction in hospital stay and costs, but no impact on clinical outcomes.[12] These data were also confirmed in other non-randomized studies, but with a high number of patients.

More recently, the NSQIP study found an increased risk of acute myocardial infarction after surgery in patients undergoing CE under general anesthesia (OR 2.18 CI).[13]

Despite the existence of several randomized controlled studies investigating the impact of anesthesia on patients undergoing CE, the total number of patients included is too small/underpowered[1] to assess the impact of anesthetic technique on clinical outcome.[14] If the results of prospective studies are added to those of retrospective studies, there would be an increasing trend to decreased mortality and improved outcome in LRA, but the number would still be insufficient.

Objectives

Evaluate the incidence of complications (medical, surgical, perioperative stroke, and in-hospital mortality up to 30 days), using LRA versus GA. Evaluate the perioperative risk factors in a tertiary center in Portugal over 10 years.

Methods

Retrospective analysis of all patients undergoing carotid endarterectomy performed after the Ethics Committee approval at the Centro Hospitalar de S. João, Porto, from January 18 2000 to 19 July 2011.

The search for the total number of patients undergoing carotid endarterectomy was performed with the IEG software, developed by the Department of Statistics and Medical Informatics, Faculdade de Medicina da Universidade do Porto. After consulting the clinical process, we excluded all wrongly coded patients, those undergoing different types of surgery during the same hospitalization, and those for whom it was not possible to identify the anesthetic technique. The exclusion of patients was performed after discussion among peers.

The assessed variables were age, sex, associated disease (hypertension, diabetes, dyslipidemia, end stage renal disease, smoking, coronary heart disease, peripheral arterial disease), surgical indication (degree of stenosis), contralateral stenosis (degree of stenosis), preoperative neurological status (unknown, asymptomatic, hemispheric TIA, retinal TIA, hemispheric stroke, retinal stroke), surgical technique, and use of shunts.

Induction of general anesthesia was performed with propofol, fentanyl or remifentanil, muscle relaxation for tracheal intubation, and maintenance with sevoflurane, opioids and muscle relaxant. Locoregional anesthesia was performed mostly under cervical plexus blockade (superficial and deep) and minimally under superficial blockade with 7.5% ropivacaine. When the carotid sheath was managed, the surgeon infiltrated with local anesthetic. Hemodynamic instability was treated according to the individual preference of the anesthesiologist. Before clamping the artery, heparinization was performed, as routine.

The neurological monitoring used for routine was agreed with the patient. In patients under general anesthesia, the stump pressure measurement was used according to the surgeon's preference. A threshold of 30–40 mmHg was used as a reference for shunt placement.

Neurological monitoring with electroencephalogram (EEG), processed EEG, somatosensory evoked potentials, transcranial Doppler, central or mixed venous saturation, and cerebral oximetry were not routinely used.

Hematoma (with or without surgical intervention), thrombosis, cranial nerve injury, medical complications, days of hospital stay, in-hospital mortality at 30 days, stroke (embolic, thrombotic, or hemorrhagic stroke associated with neurological deficit persisting for more than 24 h), and acute myocardial infarction were the postoperative variables assessed.

Data analysis was performed using the SPSS software (SPSS Inc., Chicago, IL). Chi-square test and Fisher's exact test were used in the analysis of categorical variables. Student's *t*-test was used in the analysis of continuous variables. A significance level of 0.05 was considered.

Results

In total, 750 patients who met the inclusion criteria were identified. Of these, 13 had the locoregional anesthesia converted to general anesthesia and were excluded from the remaining analysis.

Table 1 describes the conversion reasons: in seven patients (53.8%), it was not possible to identify the conversion reason; in the other, it was due to changes in mental status (30.8%). Only one patient was unable to cooperate during the whole surgery (7.7%). We also recorded a seizure after carotid sheath infiltration (7.7%). After the anesthetic technique conversion we recorded a shunt use in six patients (46.2%). In the remaining patients, it was decided to proceed with the surgery without the use of shunt. Five patients (38.5%) had a stroke during the period between the operation and 30 days after surgery. In this group, no death was identified.

Table 1 Conversion from locoregional to general anesthesia.

Age	67.8 ± 7.65
Gender (male)	11 (84.6%)
Unknown reason	7 (53.8%)
Lack of patient cooperation	1 (7.7%)
Altered state of consciousness	4 (30.8%)
Convulsion	1 (7.7%)
Use of shunt	6 (46.2%)
Cranial nerve injury	4 (30.8%)
Cervical hematoma	2 (15.4%)
Stroke <30 days	5 (38.5%)
Death <30 days	0
Days of hospitalization	7.7 ± 9.5

There were 737 patients included in this analysis. Of these, 74% underwent locoregional anesthesia and 26% general anesthesia.

There were no statistically significant differences in the distribution of age, sex, diabetes, end stage renal disease, smoking, and coronary heart disease in both groups. Hypertension and dyslipidemia were more frequent in patients undergoing locoregional anesthesia versus general anesthesia (88% vs 79% and 72% vs 65%; $p < 0.05$), respectively (Table 2).

Preoperative assessment of neurological status is described in Table 2. About 25% of patients were asymptomatic before surgery (23% vs 25%; GA vs. LRA, respectively). The remaining 75% were symptomatic. There was no statistically significant difference between groups ($p > 0.05$).

The surgical indication, degree of contralateral stenosis, and surgical technique are described in Tables 2 and 3, and there were statistically significant differences between groups.

The use of shunt was different between both groups. It was used in 14% of patients undergoing general anesthesia and in 3% of patients undergoing locoregional anesthesia, a statistically significant difference.

We found a similar percentage of cranial nerve injury in patients undergoing general and loco regional anesthesia, 6% and 5%, respectively (Table 4).

Hematomas without need for surgical intervention had the same expression in both groups (3%). However, the need for surgery was more frequent in the group undergoing general anesthesia (4% vs 2%), but without statistical significance. There were no differences regarding surgical site thrombosis. The percentage of medical complications for both groups was 4%. The most common medical complication was hemodynamic instability with hypotension and hypertension, followed by respiratory complications and airway loss.

Table 2 Demographic and baseline characteristics of the sample.

	Anesthetic technique $n = 737$	
	General anesthesia $n = 197$ (26.7%)	Locoregional anesthesia $n = 540$ (73.3%)
Age	66.5 ± 9.3	69.9 ± 9.4
Men	152 (77.2%)	427 (79.1%)
Arterial hypertension	155 (78.7%)	475 (88%)
Diabetes	60 (30.5%)	202 (37.4%)
Dyslipidemia	128 (65%)	390 (72.2%)
End stage renal disease	11 (5.6%)	31 (5.7%)
Smoking (current or former)	57 (28.9%)	182 (33.7%)
Coronary heart disease	61 (31%)	163 (30.2%)
Preoperative neurological status		
Asymptomatic	44 (22.3%)	136 (25.2%)
Hemispheric TIA	39 (19.8%)	97 (18.0%)
Retinal TIA	9 (4.6%)	13 (2.4%)
Hemispheric stroke	94 (47.7%)	273 (50.6%)
Retinal stroke	2 (1%)	3 (0.6%)
Unknown	9 (4.6%)	18 (3.3%)
Surgical indication		
50–69%	12 (6.1%)	45 (8.3%)
70–99%	164 (83.2%)	454 (84.1%)
Other	0 (0)	4 (0.8%)
Unknown	21 (10.7%)	37 (6.9%)
Contralateral stenosis		
Absent	25 (12.7%)	65 (12.0%)
<50%	56 (28.4%)	146 (27%)
50–69%	9 (4.6%)	73 (13.5%)
70–99%	14 (7.1%)	50 (9.3%)
Occlusion	20 (10.2%)	36 (6.7%)
Unknown	73 (37.1%)	170 (31.5%)

After CE, we identified 12 strokes, 6 in the GA group (1.1%) and 6 in the LRA group (3%), with no statistically significant difference.

In both groups, mortality at 30 days was around 1%; neurological cause of mortality was 0.5% and 0.35% and the cardiac cause was 0.2% and 0.5% in LRA and GA groups, respectively, with no statistically significant difference ($p > 0.05$).

Table 3 Anesthetic and surgical procedure.

Surgical technique	General anesthesia	Locoregional anesthesia
Direct closure	32 (16.2%)	62 (11.5%)
Patch	132 (67%)	403 (74.6%)
Eversion	27 (13.7%)	72 (13.3%)
Graft	1 (0.5%)	1 (0.2%)
Missing	5 (2.5%)	2 (0.4%)
Use of shunt	26 (13.2%)	13 (2.4%)

Table 4 Results.

	General anesthesia	Locoregional anesthesia
Hematoma with reintervention	8 (4.1%)	12 (2.2%)
Hematoma without reintervention	6 (3.0%)	18 (3.3%)
Thrombosis	2 (1%)	4 (0.8%)
Cranial nerve injury	11 (5.6%)	28 (5.2%)
Medical complications	7 (3.6%)	21 (3.9%)
Hypo/hypertension	2 (1%)	10 (2%)
Respiratory disease	3 (1.5%)	6 (1.1%)
Airway	2 (1%)	2 (0.4%)
Convulsion	0 (0%)	2 (0.4%)
Contrast nephropathy	0 (0%)	1 (0.2%)
Stroke at 30 days	6 (3%)	6 (1.1%)
Days of hospitalization	8.7 ± 34.0	2.4 ± 28.0
Mortality at 30 days after anesthesia		
Death of neurological cause	1 (0.5%)	2 (0.4%)
Death after myocardial infarction	1 (0.5%)	1 (0.2%)

Discussion

Despite the difficulty of quantifying the impact of the choice of anesthetic technique on the outcome of patients undergoing CE,[14] advantages and disadvantages are described.

Thus, the theoretical advantages described for LRA are the possibility of neurological monitoring with the patient awake, preservation of cerebral autoregulation, with maintenance of cerebral perfusion pressure and decreased use of shunt, and the disadvantages are the need for patient collaboration, remote access to the airway, and potential complications of cervical plexus blockade (such as paralysis of the phrenic nerve, the recurrent laryngeal, the epidural, subarachnoid or intravascular injection of local anesthetic).

GA theoretical advantages are airway control, the ability to control the $PaCO_2$, and the surgical field immobility; however, it also has theoretical disadvantages such as the decrease in sympathetic activity and blood pressure, with more frequent need for vasopressors.

After analysis, we found that the use of LRA has increased over the study period and it was the most used technique (73%). The option to use LRA in our analysis was probably due to the increased comfort of the medical-surgical team and the fact that LRA provide high quality and low cost neurological monitoring.

Other neuromonitoring techniques, such as somatosensory evoked potentials, stump pressure, electroencephalography, transcranial Doppler, and cerebral oximetry, have low specificity and/or sensitivity, high cost, difficulty of implementation, and require specific training or the presence of other health professionals for its correct interpretation.[15–17] Therefore, the awake patient monitoring with assessment of the level of consciousness, speech, and motor and sensory testing remains the gold standard.[18]

We found no differences between the preoperative characteristics assessed in both groups, except in patients with arterial hypertension and dyslipidemia who were preferentially anesthetized with LRA ($p < 0.05$). The preference of clinicians by the LRA resource can be justified by the preservation of cerebral autoregulation[19,20] and greater hemodynamic stability during surgery and in the immediate postoperative period.[11]

Selective placement of shunt was different in the two groups and there was less use in the group of patients under LRA (3% vs 14%, $p < 0.05$), difference reported in other studies.[11] This fact is relevant, as shunt placement is associated with the occurrence of complications: gas embolism, plaque, carotid dissection and tear.[21]

In the group of patients in whom LRA had to be converted to GA, we found that the most common reason was the altered state of consciousness and only one conversion was motivated by the lack of patient cooperation. According to the authors, there is no study whose objective was to analyze the outcome of patients in which it was necessary to convert the anesthetic technique; in our study, we found a high rate of perioperative complications in this group of patients, suggesting the conversion as a possible risk factor for complications in the perioperative period.

There were no statistically significant differences between the LRA and GA groups with regard to postoperative complications. We found a mortality rate of 0.6% vs 1%, which is similar to that described in the literature.[22]

The mean hospitalization time was different between groups ($p > 0.05$), it was lower in patients undergoing LRA. This result should be interpreted with some caution, as although the difference was statistically significant, the standard deviation margins are overlapping. This difference was also found in several randomized studies.[11,12] In our study, we could not find correlation between this fact and the assessed variables. So, there are some questions to be answered, such as: can the increased length of hospitalization in the group undergoing GA be associated with an increased incidence of other factors not assessed in our study, such as *delirium*, cognitive impairment, decreased quality of life, presence of recent stroke or prolonged stay for rehabilitation? Some studies have addressed this issue, but with small samples and different results.[23–27]

There are some limitations in this study. This is a retrospective study and therefore depended on the clinical process consultation to identify perioperative complications. It was not part of the study aims to evaluate the intraoperative period, we only evaluated the in-hospital mortality and we do not differentiate in-hospital from extra-hospital stroke, which may have influenced the registered number of strokes.

With this analysis we found some questions that remain unanswered and point to the need for randomized controlled studies with a large number of patients. It remains unclear how the neuromonitoring techniques should be used in CE in order to increase the sensitivity and specificity and improve the diagnosis of adverse events. We also found that only a small number of studies has addressed the impact of the anesthetic technique on *delirium*, cognitive changes, and decreased quality of life postoperatively, themes that may contribute to the clarification of the anesthetic technique impact on clinical outcome.

Conflicts of interest

The authors declare no conflicts of interest.

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