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Original article

One-year experience in carotid endarterectomy combining general anaesthesia with preserved consciousness and sequential carotid cross-clamping

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Summary. *Background and aim of the work:* We report 1-year single-centre experience in carotid endarterectomy (CEA) combining general anaesthesia with preserved consciousness (GAPC) and standardized carotid sequential cross-clamping, for our protocol effectiveness evaluation in reduction of perioperative stroke, death or cardiologic complications. *Methods:* We considered all patients who underwent CEA in 2016. All patients underwent superficial cervical plexus block and GAPC with Remifentanil. The surgical technique consisted of common carotid artery (CCA) cross-clamping, carotid bifurcation isolation, external (ECA) and internal carotid artery (ICA) cross-clamping. After CCA cross-clamping, we performed a neurological tolerance test (NTT); this allowed selective shunting only for positive NTT. Primary end-points were: transient ischemic attack (TIA)/stroke, myocardial infarction, death in perioperative period. Secondary end-points were: carotid shunting, peripheral cranial nerves injuries (PCNI), GAPC intolerance, other complications, reintervention in perioperative period, length of hospital stay. *Results:* 104 consecutive patients underwent CEA with this protocol in the considered period. Twenty-seven (25.9%) patients were symptomatic. Mean clamping time was 48±13.5 minutes. Five cases (4.8%) requested internal carotid artery shunting. No TIA/stroke, myocardial infarction or death were recorded in the perioperative period. PCNI were observed in 19 cases (18.2%) in the immediate post-operative period; 16 of them (84.2%) showed complete or partial resolution at discharge. Only one patient (0.9%) showed GAPC intolerance. No other complication occurred. Three patients (2.9%) underwent reintervention for neck haematoma drainage. Mean hospital stay were 3±0.9 days. *Conclusions:* GAPC associated with sequential carotid cross-clamping appeared to be safe and effective in prevention of major neurological and cardiologic complications during CEA. (www.actabiomedica.it)

Key words: carotid endarterectomy, local anaesthesia, remifentanil, preserved consciousness, carotid stenosis, general anaesthesia

Introduction

Significant stenosis of the carotid bifurcation caused by unstable atheromatous plaque can be found in around 20% of patients with transient ischaemic attack (TIA) or stroke (1). Carotid endarterectomy (CEA) remains the "gold standard" for stroke prevention in these cases, with precise indication especially for symptomatic patients (2).

Although CEA is a safe procedure, the neurologic complication rate reported in literature is between 3-7% (3-5). Although internal carotid artery

(ICA) acute thrombosis after CEA remain an important cause of perioperative TIA/stroke, two others mechanisms are mainly responsible for neurologic complications during CEA: cerebral hypoperfusion due to carotid cross-clamping and plaque embolization due to carotid bifurcation dissection and clamp releasing (6).

Local anaesthesia (LA) and general anaesthesia with preserved consciousness (GAPC) allows direct neurological monitoring in order to identify patients at risk for brain hypoperfusion.

Early common carotid artery cross-clamping before carotid bifurcation dissection should decrease the risk of plaque embolization by reducing the inflow to the internal carotid artery (7).

We report one-year single centre experience combining these anaesthetic and surgical techniques in order to evaluate the effectiveness of this protocol for neurologic and systemic complications prevention during CEA.

Material and methods

Study design

All patients who underwent CEA for symptomatic or asymptomatic primary carotid stenosis between January and December 2016 were considered for this study. CEA was performed for symptomatic patients with an ICA stenosis >50% (North American Symptomatic Carotid Endarterectomy Trial [NASCET]) and for asymptomatic patients with an ICA stenosis >70% (NASCET) or > to 65% (NASCET) if imaging analysis showed characteristics consistent with plaque instability (2).

For symptomatic patients, CEA was performed within 15 days from the onset of neurologic symptoms. When brain computed tomography (CT) showed a large ischemic lesion or neurologic and clinical patient's conditions were unstable, the treatment was deferred until stabilization of radiological and clinical findings, in order to reduce brain haemorrhage risk (8) or systemic complications after surgery.

Data Collection

All patient's data were prospectively collected in a dedicated database and retrospectively analysed. Demographic data were age and sex. Anamnestic collected data were hypertension (defined as systolic blood pressure >140 mmHg or need for specific drug for blood pressure control), diabetes mellitus (defined as need of hypoglycaemic drugs for glycaemic control), dyslipidaemia (defined as total blood cholesterol > to 200 mg/dl), coronary artery disease (defined as previous surgical or endovascular revascularization or history of myocardial infarction), history of smoking, renal failure (defined as glomerular filtration rate < to 60 ml/h), chronic obstructive pulmonary disease (COPD, defined as FEV/FVC < to 70%), previous or recent neurological symptoms (any TIA or stroke in the previous 6 months), previous endovascular or surgical ICA revascularization, parenchymal damage at CT analysis in symptomatic patients. Plaque's collected data were: ICA stenosis grade, plaque characteristic and peak systolic velocity (PSV). Anaesthesia collected data were: ASA status and tolerance to GAPC. Surgical data were: surgical technique (endoarterectomy and ICA angioplasty, eversion technique, semieversion technique or primary closure), time of ICA cross-clamping, intervention duration, need for shunt positioning and intraoperative complications.

Preoperative assessment, anaesthetic protocol and surgical treatment

A duplex ultrasound (DUS) was performed in all patients to diagnose the ICA stenosis, to define plaque echogenicity characteristics, to assess carotid bifurcation anatomy and to measure PSV. As second line examination, a computed tomography angiography (CTA) and a brain CT was performed in all patients in order to rule out recent ischemic lesion, to define plaque characteristics, to evaluate proximal segment of common carotid arteries, aortic arch, vertebral arteries, intracranial circulation and surgical feasibility of the procedure. If the plaque's distal endpoint wasn't visible at DUS analysis and CTA showed plaque extension over mandibular angle, the patient was proposed for carotid artery stenting (CAS).

All symptomatic patients underwent Neurological evaluation before surgery.

All patients underwent surgical intervention under antiplatelet therapy and statin. The dual antiplatelet therapy was discontinued before surgical intervention, except for patient with absolute cardiologic (recent myocardial revascularization) or neurologic (recent TIA/stroke or recent contralateral ICA stenting) indication. In these cases CEA was carried-out during dual antiplatelet therapy assumption. The oral anticoagulant therapy was discontinued five days before the treatment and switched to low-molecular weight heparin (LMWH) in all patients.

Before GAPC induction with intravenous Propofol bolus (2 mg/Kg), local anaesthesia of vocal chords with Lidocaine spray 4% (5 cc) was performed in all patients. After tracheal intubation, GAPC was continued with Remifentanil infusion only (0,025 γ/Kg.min). A superficial plexus block was performed with local infiltration of the posterior border of the sternocleidomastoid muscle with Naropine 0.37% (10 cc) and Lidocaine 2% (5-6 cc) in all cases. After surgical incision, CCA was firstly dissected. Before cross-clamping, Remifentanil infusion was slowly reduced until patients were awake and able to collaborate. The CCA was cross-clamped and the patient was asked to squeeze a soft toy for 2 consecutive minutes with contralateral hand as neurological tolerance test (NTT), in order to rule out neurological symptoms consistent with cerebral hypoperfusion or ischemia. The carotid bifurcation was then isolated and separately (ICA and ECA) cross-clamped. After complete ICA flow interruption, another minute of NTT was performed. If the NTT was positive for brain hypoperfusion, the Remifentanil infusion was implemented and a shunt was positioned. The endoarterectomy was then carried out with different techniques, according to operator experience and ICA anatomy. When the procedure was completed, Remifentanil infusion was reduced for a new NTT.

Follow-up was performed with clinical assessment and DUS at 30 days from surgery.

End points

Primary end points were: transient ischemic attack (TIA), stroke, myocardial infarction and death in the perioperative period (30 days).

Secondary end points were: need for carotid shunting, peripheral cranial nerves injuries (PCNI) (all patients underwent Otorhinolaryngologist on first post-operative day and after 30 days), patient's intolerance to GAPC, other systemic complications (cardiac arrhythmias, respiratory complications) in perioperative period, need of reintervention in the perioperative period and length of hospital stay.

Statistical analysis

Quantitative data are presented as mean ± standard deviation, while categorical data are given as counts and percentage. All statistical analyses were performed using SPSS software (version 13.0; SPSS Inc, Chicago, IL, USA).

Results

Population

One hundred four patients (male: 70 [67.3%]; mean age:73.3±8.1 years) underwent CEA with GAPC and sequential carotid cross-clamping. No patients were bilaterally treated in this period. Twenty-seven patients (25.9%) were treated for symptomatic stenosis with 2.1±1.3 weeks of delay between neurologic symptoms and surgical treatment. Patient's characteristics are described in Table 1 and 2.

Procedure

In the considered period, 104 CEA were performed in 104 patients with the described anaesthetic and surgical protocol. The CEA technique was chosen according with ICA anatomy and surgeon experience. Sixty-six patients (63.4%) underwent CEA and ICA angioplasty with dacron patch (Hemacarotid Patch, Maquet®, Getinge Group), 27 patients (25.9%) underwent eversion technique, 8 patients (7.7%) semieversion technique and 3 patients (2.9%) CEA and direct closure. Mean intervention time was 97.8±26.6 minutes and mean cross-clamping time was 48.2±13.5 minutes.

Table 1. Patient's characteristics

	N	%
Male	70	67.3
Age (median± standard dev.)	73.3±8.1	
Hypertension	89	85.6
Dyslipidaemia	77	74
Diabetes	32	30.7
Active Smoker	28	26.9
Coronary artery disease	27	25.9
Chronic kidney disease	18	17.3
Previous controlateral carotid treatment	22	21.1
ASA 2	9	8.6
ASA 3	88	84.6
ASA 4	7	6.7
Controlateral ICA occlusion	1	0.9
Dual antiplatelet therapy[1]	18	17.3
LMWH[2]	8	7.7

ICA: internal carotid artery; LMWH: low molecular weight heparin
1: patients undergoing CEA without dual antiplatelet therapy interruption
2: patients undergoing CEA with LMWH

Table 2. Clinical presentation of symptomatic patients

	Tot. N	%
Symptomatic	27	25.9
TIA	15	55.5
Minor Stroke	5	18.5
Major Stroke	4	14.8
Amaurosis Fugax	3	11.2
Parenchymal lesion at brain CT omolateral to carotid stenosis	19	70.4

TIA: transient ischemic attack; CT: computed tomography

End-points

No TIA/stroke, myocardial infarction or death were observed in the perioperative period.

A carotid shunt was positioned in 5 cases (4.8%). In 4 cases (3.8%) the shunt was positioned for positive NTT. In 1 case the shunt was necessary because of general anaesthesia conversion for patients intolerance to GAPC.

PCNI was observed in 19 (18.2%) patients at the end of intervention. Sixteen (84.2%) of these patient's symptoms were partially or completely resolved at 30 days.

Only 1 patient (0.9%) showed intraoperative intolerance to GAPC and conversion to GA was necessary.

No other cardiac or respiratory complications were observed during the perioperative period.

Three patients (2.8%) underwent reintervention in the first post-operative day for neck haematoma. Two (66.6%) of these patients were under anticoagulant therapy with low molecular weight heparin (LMWH) for atrial fibrillation.

Mean length of hospital stay was 3±0.9 days.

Discussion

In this experience, GAPC associated with carotid sequential cross-clamping appeared effective for prevention of neurologic and cardiologic complications, with reliable detection of intraoperative cerebral symptoms and a low rate of carotid shunting. GAPC appeared also well tolerated by patients and surgeons, with a low rate of conversion to GA (0.9%).

CEA is the first treatment option in our centre for patients with haemodynamic carotid stenosis and CAS is reserved for selected patients with specific indications (2). In the considered period 116 patients referred to our centre for symptomatic or asymptomatic carotid stenosis, and only 12 CAS procedures (10.3%) were performed.

Although CEA is a safe procedure and remains the "gold-standard" for treatment of symptomatic and asymptomatic carotid stenosis (2), 3-7% of these procedures are complicated by disabling or nondisabling strokes (3-5). Acute carotid thrombosis (ACT) after CEA remains an important cause of neurologic complications. Surgical precision during the phase of endarterectomy is crucial to avoid this complication. Two other causes of neurologic complication during CEA are plaque embolization and brain hypoperfusion during ICA cross-clamping (6). In order to limit these phenomenon and reduce the rate of perioperative neurological event, we associated GAPC for better cerebral perfusion monitoring during CEA with sequential carotid cross-clamping in order to reduce plaque embolization.

The GALA Trial showed similar results between LA and GA during CEA, with slightly lower rate of perioperative TIA/stroke occurrence, myocardial infarction and death for LA. However, these differences had no statistical significance (9).

In other experiences LA showed many advantages over GA in term of myocardial infarction reduction, haemodynamic stability and cost effectiveness (10). Kfoury et al (11) showed superiority of LA over GA in terms of reduction of neurologic (OR=2.64, 95% CI: 1.09-6.85) and cardiologic complications (OR=7.33, 95% CI: 0.82-347.3) on 1127 procedures carried out under either general or local anaesthesia (11).

GAPC demonstrated to be a safe procedure, comparable to LA in term of neurologic and cardiologic complications (12-15).

The role of NTT is not well defined in literature and no clear evidence regarding superiority of selective over routine shunting are available (1). Although this lack of evidences, some experiences provides important information about patients at high risk for neurologic intraoperative complications identified by intraoperative NTT and shows the importance of selective shunting in these patients (16, 17).

GAPC allows a reliable neurologic monitoring, with strictly selective shunting (4.8% in our experience). Internal carotid artery shunt placement, although is a safe procedure, can bring adjunctive complications due to arterial wall damage and could lead to a longer intervention time (17). In our experience, the mean internal carotid clamping time was 48.2±13.5 minutes and no perioperative TIA/stroke occurred.

These data may suggest that ICA clamping time during CEA doesn't influence perioperative neurological outcome. Also in the 27 symptomatic patients, with extremely unstable plaque, no neurological complications occurred during perioperative period, showing the effectiveness of this anaesthetic and surgical technique for reduction of complications after CEA.

Our experience showed a rate of reintervention in the perioperative period of 2.8%, aligned with other experiences (9). All reintervention were performed for neck haematoma development and consisted in surgical drainage on first post-operative day. In 2/3 of cases, this complication occurred in patients with atrial fibrillation receiving LMWH twice daily. The increased risk of haemorrhagic complications after CEA in patients receiving LMWH is been already reported in literature (18).

Also the surgical technique plays an important role for prevention of neurologic complications. The preliminary CCA dissection and cross-clamping may reduce the risk of embolic event, that are mainly responsible for hypoperfusion or intraoperative stroke during CEA (15). Once the CCA is cross-clamped and the ICA blood flow is interrupted, the ICA dissection can be performed with lower risk of plaque embolization (7).

This study present a preliminary experience limited by the small sample size and the retrospective analysis, although the data were prospectively collected.

Conclusions

CEA performed under GAPC with standardized carotid cross-clamping technique is a safe protocol for reduction of neurological and cardiologic complications, allowing reliable neurologic monitoring and stable anaesthetic management. This protocol has shown to be also well tolerated by patients and surgeons, with a low rate of conversion to GA.

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