Regional Anesthesia with Dexmedetomidine Infusion: A Feasible Method for the Awake Test during Carotid Endarterectomy

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Background: Carotid endarterectomy (CEA) is the standard treatment modality for the prevention of stroke in patients with carotid stenosis. This study reports our experiences during CEA with routine awake tests under regional anesthesia (RA) combined with light sedation by dexmedetomidine infusion.

Materials and Methods: We retrospectively reviewed 23 patients who had undergone CEA between April 2013 and June 2015. All patients underwent the awake test during CEA with cervical plexus block and light sedation by continuous dexmedetomidine infusion.

Results: Mean operation and clamp times were 108.5 ± 20.1 min and 30.1 ± 6.9 min, respectively. Selective shunt placement was performed in three patients (13.0%). There were no cases of perioperative stroke, myocardial infarction, or death. There were no occurrences of residual stenosis, thrombosis, or dissection. One patient had a hypoglossal nerve injury but fully recovered before discharge. Mean (± standard deviation) hospital stay was 7.5 ± 2.6 days. There were no incidences of death, stroke, or restenosis during a mean follow-up period of 9.2 ± 8.8 months.

Conclusions: RA with dexmedetomidine infusion appears to be a safe and feasible option. A lower shunt placement rate and favorable patient outcomes were observed following the awake test during CEA.

Keywords: carotid arteries, endarterectomy, cervical plexus block, awake test, dexmedetomidine

Introduction

Carotid endarterectomy (CEA) is the standard treatment modality for the prevention of stroke in patients with carotid stenosis. The routine use of a shunt has been debated owing to the different mechanisms of stroke: hypo-perfusion versus embolic. Theoretically, the use of a shunt is only reasonable when hypo-perfusion occurs while the artery is clamped.

There is a diverse range of monitoring devices available for cerebral perfusion including stump pressure measurements, electroencephalography, somatosensory evoked potentials, measurements of middle cerebral artery flow of transcranial Doppler, and cerebral oxygen saturation. However, none of these can directly assess cerebral ischemia. A recent study has shown that the awake test is the most reliable method for detecting hypo-perfusion and reducing the use of shunt.1) Maintaining the depth of anesthesia is important for a successful CEA; however, this is difficult owing to the occurrence of patient pain and anxiety in CEA procedures. The aim of this study was to evaluate the feasibility of anesthesia using dexmedetomidine with cervical plexus block during the awake test.

Materials and Methods

Patients

Prospective data of 23 patients who had undergone CEA with the awake test between April 2013 and June 2015 in Pusan National University Hospital (single center) were retrospectively reviewed. Patient baseline data are presented in Table 1. The indication of CEA was at least 70% stenosis of the internal carotid artery regardless of symptoms. Symptomatic patients were identified by the history of a transient ischemic attack or stroke within a 3-month period prior to the surgery. In each case, brain magnetic resonance imaging, computed tomography angiography, and computed tomography perfusion or cerebral angiography were performed. Symptoms and lesion characteristics are described in Table 2.
We evaluated the shunt rate and identified factors related to selective shunt placements during CEA with the awake test. Three patients who had undergone CEA under general anesthesia (GA) during the same period were excluded. In two of these patients, the location of carotid stenosis was too high (C2 level) to expose the lesion without excessive traction that can cause severe pain and anxiety under regional anesthesia (RA). The remaining patient had a neurological deficit: hand motor weakness prohibiting neurological examination in the awake test.

In the preoperative process, blood pressure was controlled in normal ranges and after CEA and declamping, blood pressure was controlled at systolic blood pressure 120 mmHg aggressively. Anti hypertensive drug used before surgery was kept and for the concerning patients to suffer from hypo-perfusion due to low blood pressure before surgery, anti hypertensive drug was stopped and hydration was performed to keep the normal blood pressure.

Anesthesia and surgery
All cases of CEA were performed under RA with a deep cervical block guided with ultrasound. After the cervical block, the patient was continuously infused with dexmedetomidine. The loading and maintenance doses were 1 mcg/kg/min and 0.4–0.6 mcg/kg/min, respectively. The target level of sedation was 2 on Richmond Agitation–Sedation Scale (a light sedation). The light sedation state is characterized as an awakening by other voices and maintenance of eye-contact for 10s. Five minutes before artery clamping for CEA, we performed the awake test using speech, grasping a rubber ball, and toe movements. We performed the awake test immediately after clamping and then at every 5 min. For the rubber ball test, a noise for grasping a rubber ball was initiated in the contralateral carotid stenosis. Successful grasping of the rubber ball was classified as motor grade 5. If the rubber ball did not produce a sound, the patient had inarticulate speech, or the toes were unreactive, we performed carotid artery shunting (Pruitt-Inahara carotid shunt with T-port; LeMaitre vascular Inc., Burlington, MA, USA).

Follow-up
Immediately after each surgery, computed tomography angiography was performed for confirmation of vascular patency and diagnosis of acute thrombosis (Fig. 1). Blood pressure was monitored during the 24h after surgery and strictly controlled below 140 mmHg of systolic blood pressure. After discharge, a carotid Doppler was performed every 3 months in the follow-up period.

Results
There was no conversion to GA and the awake tests were performed successfully in all patients. Selective shunt placement was carried out in three patients (13.0%). All the three patients who needed shunt had contralateral severe stenosis or occlusion. Surgical data and outcomes are described in Table 3. No cases of residual stenosis, thrombosis, or dissection were observed by computed tomographic angiography immediately after surgery (Table 3).

There were no incidences of perioperative stroke, myocardial infarction, or death. A single case of hypoglossal nerve injury was recorded; however, the patient fully recovered prior to discharge. Mean ± standard deviation hospital stay was 7.5 ± 2.6 days. There were no cases of death, stroke, restenosis, or re-intervention during a mean follow-up period of 9.2 ± 8.8 months (Table 4).

Discussion
CEA is the standard procedure for the prevention of stroke in patients with atherosclerotic carotid stenosis. The CEA procedure has progressed to enable the prevention of both embolic and ischemic perioperative

<table>
<thead>
<tr>
<th>Table 1 Patient baseline characteristics and comorbidities</th>
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<tr>
<td><strong>Characteristics</strong></td>
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<td>Mean (± SD) age</td>
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<tr>
<td>Men</td>
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<td>Hypertension</td>
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<td>Diabetes mellitus</td>
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<td>Dyslipidemia</td>
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<td>Overweight (BMI &gt;25 kg/m²)</td>
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<td>Coronary artery disease (previous PCI)</td>
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<td>Chronic obstructive pulmonary disease/asthma</td>
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<td>Peripheral arterial disease</td>
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<td>Renal insufficiency (eGFR &lt;40)</td>
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*One patient had recent myocardial infarction. BMI: body mass index; eGFR: estimated glomerular filtration rate; PCI: percutaneous coronary intervention; SD: standard deviation

<table>
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<th>Table 2 Symptoms and lesion characteristics</th>
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<td><strong>Parameters</strong></td>
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<tr>
<td>Asymptomatic</td>
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<tr>
<td>Symptomatic</td>
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<td>Cerebral infarction</td>
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<td>TIA</td>
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<td>Amaurosis fugax</td>
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<td>Near total occlusion</td>
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<td>Level of stenosis</td>
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<td>C3</td>
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<td>Contralateral severe stenosis or occlusion</td>
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TIA: transient ischemic attack; Near total occlusion: the string sign on the computed tomography or cerebral angiography; C3: third cervical spine; C4: fourth cervical spine
According to AbuRahma et al., there are various methods available for cerebral monitoring in selective shunting cases. Perioperative stroke rates associated with the electroencephalogram, transcranial Doppler, carotid stump pressure, and somatosensory evoked potential methods are 1.6%, 4.8%, 1.6%, and 1.8%, respectively. However, all of these methods have a relatively low sensitivity for detecting inadequate cerebral perfusion and intraoperative stroke. For this reason, it is possible to reduce shunting-related risks using selective shunting only for the patients who require the procedure.

According to AbuRahma et al., the routine use of a carotid shunt during CEA is widespread, but remains controversial. Several large series of CEA without shunting have documented satisfactory results: the perioperative stroke rate is approximately 2%. However, CEA with carotid shunting is theoretically more favorable than CEA without shunting in patients who are at risk of cerebral ischemia. One study demonstrated that routine carotid shunting is superior to CEA without shunting: a stroke rate of 1.4%. However, shunting may be associated with risks such as intimal damage, promoting early postoperative thrombosis, and late restenosis, leading to stroke. For this reason, it is possible to reduce shunting-related risks using selective shunting only for the patients who require the procedure.

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Observations also indicate a hemodynamic advantage of propofol anesthesia during carotid clamping. However, there is currently no outcome-based evidence suggesting the superiority of any particular general anesthetic agent during carotid clamping. The main disadvantage of GA is that its residual effects in the early postoperative period can mask the symptoms or signs of neurological complications during surgery.

In contrast, the advantage of RA is that the operator can closely monitor the neurological function during surgery. The operator can directly monitor a variety of changes caused by inadequate cerebral perfusion after carotid artery clamping, such as consciousness, speech, and muscle function. Other benefits of RA comprise the avoidance of expensive neurological monitoring, stable blood pressure, reduced vasopressor requirements, and preserved cerebral autoregulation of perfusion.

Despite its advantages, RA requires patient cooperation. We generally performed CEA under RA with deep cervical block. Cervical block is not sufficient enough to maintain the stability of the patient due to anxiety, uncomfortable neck extension position, and traction pain. Therefore, we excluded a patient in whom the location of carotid stenosis was too high (C2 level).

We overcame the limitations of RA by administering a continuous infusion of dexmedetomidine under RA. Dexmedetomidine is a selective alpha-2 adrenoreceptor agonist with sedative, analgesic, and anesthetic-sparing effects. It is well known that dexmedetomidine does not depress respiratory function and patients can be easily awakened following its use. Owing to its central sympatholytic effects, dexmedetomidine is safe and it is associated with favorable hemodynamics. McCutcheon CA et al. performed a randomized, double-blind study in 56 patients undergoing CEA under RA, and compared hemodynamic control with dexmedetomidine versus a conventional sedation technique with midazolam and fentanyl standard. The nature of interventions differed in that patients in the dexmedetomidine group were less likely to require treatment for hypertension and/or tachycardia (dexmedetomidine, 40% vs. standard, 72%; P = 0.03). The number of interventions per patient for hypertension and/or tachycardia was also fewer in the dexmedetomidine group (P = 0.02). There were no significant differences in the number of patients needing intraoperative treatment for hypotension or bradycardia or in the need for intra-arterial shunting. The number of patients requiring no additional pain relief in the postanesthesia care unit was significantly larger for patients in the dexmedetomidine group (dexmedetomidine, 18 (72%) vs. standard, 11 (38%); P = 0.027). To compare with remifentanil, a literature search was conducted to identify the evidence about the effects of dexmedetomidine and remifentanil in patients undergoing awake CEA with RA. Four randomized control studies and a retrospective study were critically appraised to evaluate the evidence on the effectiveness of dexmedetomidine compared with remifentanil during CEA, from trials on the use of RA and dexmedetomidine or remifentanil from 2004 to 2009. These studies found that dexmedetomidine provides adequate sedation with less respiratory depression than does remifentanil when used in adjunct to RA, allowing the provider to monitor hemodynamic stability and neurologic status continuously during the intraoperative period.

Perioperative management of hypertension is very important in patients undergoing CEA. Preoperative hypertension is a significant risk factor of postoperative hypertension, whereas postoperative hypertension is a major risk factor of cerebral hyper-perfusion syndrome (CHS). RA produces greater cardiovascular stability than GA, potentially due to improved postoperative analgesia of the cervical block.

In cases when blood pressure is not sufficiently controlled in the postoperative period, CHS can lead to unfavorable consequences. The pathophysiology of CHS comprises impaired cerebral autoregulation, postoperative hypertension, and ischemia reperfusion injury. According to Konstantinou and colleagues, CHS is rare (1.9%) and has a variety of clinical presentations including deterioration of consciousness, confusion (37.1%), headache (30.6%), epileptic disturbances, focal seizure (25.8%), and motor disturbances, hemiparesis, and hemiplegia (17.7%).

Bekker et al. reported a randomized, double-masked, and placebo-controlled study assessing the benefits of incorporating sedation with dexmedetomidine infusion during awake CEA. The authors obtained similar intraoperative neurological examination results in both patient groups, without and with dexmedetomidine. Furthermore, they reported significant attenuation of patient anxiety in the dexmedetomidine group. The perioperative requirement of antihypertensive therapy in the dexmedetomidine group was significantly lower than in the control group.

This study has a few limitations. The size of the sample group was small (N = 23) and the study design was a non-randomized, retrospective review. In addition, we could not manage all patients equally because in some patients the location of carotid stenosis was too high, whereas some patients could not undergo the grasp test due to neurological deficit.

**Conclusion**

Incorporation of dexmedetomidine administration in the awake test under RA can reduce patient anxiety and enhance hemodynamic stability during surgery using the reliable awake test. By performing the awake test, we...
were able to reduce the rate of selective shunting. Favorable outcomes were observed with no incidences of stroke, death, or re-stenosis in the perioperative and follow-up periods. Our study supports the use of dexmedetomidine infusion as a safe and feasible option for CEA with RA for the awake test in selective patients.

**Acknowledgement**

This study was supported by the Biomedical Research Institute Grant (2015–30), Pusan National University Hospital.

**Disclosure Statement**

All authors have no conflict of interest.

**Authors Contributions**

Study conception: SS, SWC
Data collection: SS, SMS, HJC
Analysis: SS, CWL
Investigation: SS, JL, UH
Writing: JL, UH
Funding acquisition: none
Critical review and revision: all Authors
Final approval of the article: all Authors
Accountability for all aspects of the work: all Authors

**References**


