Carotid endarterectomy (CEA) has long been known to reduce the risk of ischemic stroke in patients with significant carotid stenosis. At the same time, the procedure has been a center of controversy vis-à-vis the choice of anesthesia it should ideally be performed under. Both general anesthesia (GA) and regional anesthesia (RA; superficial/deep cervical block or local infiltration) have their proponents. Among practitioners using RA for CEA, combined deep and superficial cervical plexus blocks are the most frequently used technique. These blocks are relatively easy to learn and reliable in practice. With a number of retrospective reviews having been done, recent guidelines tend to build a consensus of safety concerns between GA and RA. Nevertheless, many medical centers, especially in developing countries, tend to prefer LA for CEA surgery given the shorter hospital stays and associated cost savings.

In 1987, Dr. John Youngberg forwarded the argument that RA is superior to GA for CEA.[1,2] The potential benefit of RA for CEA stressed the theoretical advantage of monitoring an awake patient for new neurologic deficits compared to the inaccuracies of cerebral monitoring in an anesthetized patient. In an awake patient, intra-arterial shunts are placed when indicated by patient assessment. Therefore, shunt use (and the associated risks of dissection, thrombus formation, or atheromatous embolism and resulting neurologic deficits) could be reduced in patients with RA. Cardiac morbidity may be reduced with avoidance of GA. Finally, RA would allow quicker postoperative recovery and shorter intensive care unit and hospital lengths of stay.

Analysis of recent data shows that these theoretical advantages of RA may be supported by outcome data.[3] Data from 13 manuscripts which compare outcome in a total of 7619 patients having either RA or GA for CEA were reviewed. Primary outcome was defined as the incidence of postoperative transient ischemic attack (TIA), stroke, myocardial infarction (MI), and death [Table 1]; secondary outcomes included the incidence of shunt placement, hospital and intensive care unit lengths of stay, hospital charges, and postoperative hemodynamic stability and use of vasoactive agents. Two of these studies report data from prospective trials,[4,5] whereas the remainder is retrospective reviews. Three of these studies[6-8] show a significant improvement in primary outcome with RA and deserve special comment.

Allen et al.[6] report on 679 consecutive carotid endarterectomies in 584 patients. MI occurred in nine patients in the GA group (2.5%) and in two patients in the RA group (0.6%), *P* = 0.07. Cardiopulmonary complications occurred in thirty operations (8.3%) performed under GA and in only 13 (4.1%) operations with cervical block, *P* = 0.03. Becquemin et al.[7] retrospectively studied a series of 385 carotid endarterectomies and found 10 MIs documented by ECG or cardiac enzyme changes in the GA group, and no MIs in the RA group, *P* < 0.05. Five of these 10 MIs were fatal. They concluded that RA by cervical plexus block was more appropriate than GA in patients with coronary artery disease. Corson et al.[8] retrospectively compared 368 patients having 399 CEAs under either general or cervical block anesthesia and found a significantly (*P* < 0.025) higher stroke rate in the GA group.

The paper by Rockman et al.[9] reports on the largest number of patients. This study is a retrospective review of a 32-year period, in which 3975 carotid operations were performed. There was no difference in primary outcome between GA and RA groups. One might argue, however, that over these 32 years, patient selection, surgical practice, and anesthetic care have changed, and therefore, these results may not be representative of current outcome. The authors recognized...
this limitation and performed a secondary evaluation of outcome by year of operation. When evaluating the most recent data, for example, from 1985 to 1994, Rockman et al. report on 1763 operations (1414 regional and 349 general). The incidence of perioperative MI (1.2% general group vs. 0.6% regional group) and perioperative mortality (0.9% general group vs. 0.9% regional group) is similar in the two groups. The perioperative stroke rate, however, was significantly different between groups (3.2% general group vs. 1.2% regional group; \( P < 0.01 \)). Analysis of this subgroup revealed that the use of GA (\( P < 0.02 \)) and a history of preoperative stroke (\( P < 0.01 \)) were found to be significantly associated with perioperative stroke. If one combines this accumulated experience, there are data on 7619 CEA operations. Analysis of the combined data shows no difference in MI and perioperative mortality. There is a threefold difference, however, in the incidence of stroke and TIAs between groups, 3.9% in general group versus 1.1% in regional group, \( P < 0.001 \). There were also significant advantages in the RA group for secondary outcomes.\(^{[13]}\)

Proponents of GA argue that RA is associated with a lack of airway control, conversion to GA is often required for a failed block and that cervical block is associated with potentially dangerous hemidiaphragmatic paralysis. Although these concerns are real, data suggest they are not common. The conversion from RA to GA is low. Shah et al.\(^{[10]}\) report that seven of 654 CEAs under RA were converted to general (1.1%). Four of these were for inadequate anesthesia and three were for airway control. Corson et al.\(^{[9]}\) report that 5 of 157 patients (3.2%) converted to GA secondary to inadequate anesthesia. Castresana et al.\(^{[11]}\) studied diaphragmatic motion in 28 patients having deep cervical plexus block for CEA and report abnormalities in hemidiaphragmatic motion in 61% of patients by fluoroscopy. These abnormalities were associated with a statistically significant rise in \( \text{PaCO}_2 \) from 36 + 1 mmHg preblock to 40 + 1 mmHg postblock. Although this is a difference, the clinical physiologic consequence of these changes is insignificant. Monitoring of cerebral function under GA is also fraught with inconsistency. In a recent report by Stoughton et al.,\(^{[12]}\) 208 consecutive carotid endarterectomies were prospectively evaluated for cerebral function during surgery under RA with simultaneous mental status evaluation and intraoperative electroencephalographic (EEG) monitoring. The authors found a high incidence of false-positive (6.7%) and false-negative (4.5%) EEG results in the detection of neurologic deficits when compared to an awake mental status evaluation. If the correlation is so bad in an awake patient, one must wonder what the utility is in an anesthetized patient. Assessment of neurologic function in the awake individual avoids all ambiguity in other surrogate testing modalities. Clearly, there are instances when GA is the preferred technique. Obviously, in uncooperative patients, claustrophobic patients, patients with tremor or cough, and some others, GA may be required. In addition, institutional data should be a primary consideration when evaluating a change in anesthetic technique. For example, many anesthesiologists and surgeons have a long institutional record of successful carotid operations under GA with or without shunt. If results are good, then a change in technique may not improve outcome.

As a general statement, RA is associated with a reduced incidence of perioperative neurologic deficit. In addition, regional anesthesia results in reduced shunt placement, reduced hospital utilization, reduced hospital charges, and improved postoperative hemodynamics. The technique is safe, and there are few conversions to GA for failed block or airway control. We in our center prefer locoregional anesthesia for almost all

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**Table 1: Primary outcome from the cumulative results of 13 studies of carotid endarterectomy**

|                  | Regional, \( n \) (%) | General, \( n \) (%) | \( P \) |
|------------------|-----------------------|-----------------------|--------|
| Totals           | 5362                  | 2257                  |        |
| Stroke/TIA       | 60 (1.1)              | 89 (3.9)              | <0.0001|
| MI               | 68 (1.3)              | 37 (1.6)              | NS     |
| Death            | 60 (1.1)              | 32 (1.4)              | NS     |

NS: Not significant, TIA: Transient ischemic attack, MI: Myocardial infarction
cases except when called for combined cases with coronary artery bypass grafting [Figures 1 and 2].

Finally, RA allows for the best intraoperative monitoring of neurologic status - an awake patient. Therefore, in my opinion, for most patients, RA is superior to GA for patients having CEA.

Declaration of patient consent
The authors certify that they have obtained all appropriate patient consent forms. In the form the patient(s) has/have given his/her/their consent for his/her/their images and other clinical information to be reported in the journal. The patients understand that their names and initials will not be published and due efforts will be made to conceal their identity, but anonymity cannot be guaranteed.

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Conflicts of interest
There are no conflicts of interest.

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