Regional anaesthesia techniques for carotid surgery: the state of art

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Received: 14 February 2014 / Accepted: 7 April 2014 / Published online: 1 May 2014
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Abstract

Purpose This review will analyse some aspects of regional anaesthesia (RA) for carotid endarterectomy (CEA), a surgical procedure which requires a strict monitoring of patient's status. RA remains an important tool for the anaesthesiologist. Some debates remain about type and definition of regional anaesthesia, efficacy and safety of the different cervical block techniques, the right dose, concentration and volume of local anaesthetic, the use of adjuvants, the new perspectives: ultrasonography, the future directions.

Methods A literature search was performed for journal articles in English language in the PubMed Embase and in The Cochrane Library database, from January 2000 to

December 2013. The electronic search strategy contained the following medical subject headings and free text terms: local anaesthesia versus general anaesthesia for endarterectomy, superficial and deep cervical block, complications of cervical nerve block, ultrasound guidance of superficial and deep cervical plexus block.

Conclusions The gold standard for RA will be achieved after overcoming a number of limitations by a more extensive use of ultrasonography, by combining general and regional anaesthesia, including conscious anaesthesia, by defining the appropriate volume, concentration and dosage of local agents and by addition of adjuvants.

Keywords Carotid surgery · Local anaesthesia · Ultrasonography · Cervical plexus

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Riassunto

Obiettivo La presente review analizza alcune problematiche riguardanti l'anestesia regionale (AR) nella chirurgia

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della carotide, endoarterectomia carotidea (EAC) procedura chirurgica che richiede un attento monitoraggio dello stato neurologico e clinico del paziente. L'AR continua ad essere una metodica, alternativa all'anestesia generale (AG), importante per l'anestesista. Permangono, tuttavia, alcuni punti di discussione sul tipo e la definizione della AR, sull'efficacia e la sicurezza delle differenti tecniche di blocco del plesso cervicale, sul dosaggio, la concentrazione ed il volume di anestetico locale più appropriati, sull'uso di farmaci adiuvanti, sulle nuove prospettive: l'ultrasonografia e le sue future applicazioni in questo ambito.

Metodi E' stata eseguita una ricerca bibliografica sui principali database, Pubmed Embase e The Cochrane Library dal gennaio 2000 al dicembre 2013. Sono stati utilizzati nella ricerca elettronica le seguenti parole chiave ed associazioni di termini medici: anestesia locale versus anestesia generale nell'endoarterectomia carotidea, blocco del plesso cervicale superficiale e profondo, complicanze del blocco nervoso cervicale, blocco del plesso cervicale profondo e superficiale ecoguidato.

Conclusioni Il *gold standard*, nell'esecuzione dell'AR, per interventi di EAC, sarà possibile solo superando alcune limitazioni legate alle tecniche anestesilogiche tradizionali. Ciò sarà ottenuto grazie ad un uso più appropriato e specifico dell'ultrasonografia, in questo ambito, ad una sempre maggiore integrazione di tecniche regionali con l'anestesia generale, includendo in quest'ultima anche la cosiddetta "*conscious anaesthesia*", ad una precisa definizione del volume, della concentrazione e del dosaggio di AL più appropriati ed all'aggiunta di farmaci adiuvanti alla soluzione anestetica.

Introduction

Carotid endarterectomy (CEA) has been shown to reduce the risk of stroke in patients with symptomatic 70–90 % stenotic lesions; less evident are the advantages of the procedure for stenosis of lower grade (50–69 %) [1–3]. Perioperative strokes usually occur during the procedure and may relate to the decrease of blood flow during carotid clamping [4].

Therefore, protection of brain during carotid cross-clamping represents a major concern [5]. CEA is a surgical intervention requiring an appropriate monitoring of "patients well being" [6].

The beneficial effects of the procedure, therefore, require a low operative risk considering the general status of patient [7].

Available evidence from the literature does not clarify whether regional anaesthesia (RA) for CEA is superior to general anaesthesia (GA). Recently, Rerkasem and Gala trial

provide no evidence to prefer one anaesthetic technique over the other and support the policy that patients and surgeons can choose either anaesthetic technique depending on the clinical situation and their preferences [8, 9].

These conclusions were, recently confirmed by two retrospective studies comparing GA and RA for CEA [10, 11]. Different anaesthetic techniques represent a set of care with potentially positive or negative effects [12].

Hariharan obtained a good perioperative CEA outcome under RA in a setting of developing countries with limited resources for intraoperative neurological monitoring [13].

The aim of the present review is to describe the state of art of RA during CEA and to identify the procedures that can optimise cervical plexus block. In the first part of the review, the traditional techniques, advantages and disadvantages, and the open issues of RA are analysed. Whilst, in the second part, we will describe the procedures (administration of adjuvants, ultrasonography, and the combined regional general anaesthesia), that can reduce some of the limits of traditional technique.

Methods

A literature search was performed for journal articles in English language in the PubMed Embase and in The Cochrane Library database, from January 2000 to December 2013. The electronic search strategy contained the following medical subject headings and free text terms: local anaesthesia versus general anaesthesia for endarterectomy, superficial and deep cervical block, complications of cervical nerve block, ultrasound guidance of superficial and deep cervical plexus block.

We also searched cited references of relevant reports and reviews for potentially eligible studies. Although we included articles involving a case report, case series and anatomical ultrasound reports, we limited these to studies involving series containing some interesting and innovative findings.

Cervical plexus block

Cervical plexus can be blocked either deeply, or superficially. A third option is to proceed through a combination of deep and superficial plexus block. Both techniques are well established and supported by literature data [14, 15].

A prospective study has demonstrated that the combined superficial-deep block is more effective in producing muscle relaxation [16]; other authors, however, have demonstrated that CEA can be successfully performed either under the combined block or the simple superficial cervical blockade [17–20].

Deep cervical plexus block (DCPB) appears more effective as it requires less additional local anaesthetic when paraesthesia is elicited or a nerve stimulator is used [21, 22]. Nevertheless, potential complications associated with this procedure result in a higher conversion rate to GA [20, 23].

The procedure for the superficial cervical plexus block (SCPB) results in a much easier technique than the one performed for the DCPB. Classical techniques have been described by Murphy and Scott [24, 25].

Theoretically, SCPB alone may be insufficient to relax neck muscles, and this may impair the dissection of deeper cervical structures. Local anaesthetic infiltration of jaw inferior border, blocking afferent branches from facial nerve, may reduce pain associated with prolonged use of retractor at the cephalic end of incision.

In 2004, Telford and Stoneham reclassified cervical plexus block, defining as “intermediate” block the injection of local anaesthetic (LA) between the superficial and deep cervical fascia [26]. The concept of intermediate cervical plexus block arises from 2003 anatomical studies [27].

The authors showed that the deep cervical fascia is permeable [27]. Recently, other investigators demonstrated that the intermediate cervical plexus block (ICPB) may overcome practical difficulties of Moore’s DCPB, by reducing the risk of life-threatening complications and achieving the criteria of technical feasibility, efficacy, and safety [28].

Advantage and disadvantage of RA versus GA

Regional anaesthesia has been claimed to have major advantage as a strict monitoring of patients allows to detect brain ischaemia during clamping of the carotid artery and to prevent neurological complications. Several methods to monitor cerebral blood flow directly or indirectly (electroencephalography, measurement of internal carotid artery back pressure, transcranial Doppler monitoring, and somatosensory-evoked potential monitoring) were used. None of these methods are particularly sensitive or specific for detecting intraoperative cerebral hypoperfusion, so no consensus has been found yet regarding the best modality for cerebral perfusion monitoring [29].

Recently, Ritter showed that cerebral oximetry (CO) measuring regional saturation of oxygen (rSO₂) is a reliable method of monitoring cerebral perfusion during CEA under RA and concluded that CO, using a cut off of ‘–19 %’ drop in rSO₂, has a high sensitivity and specificity when compared with awake testing [30]. Nevertheless, CO cannot be considered a reliable method of identifying patients requiring a shunt during CEA under GA [31].

The advantages of regional anaesthesia include: strict monitoring of brain functions, in particular during carotid cross-clamping, preservation of cerebral and systemic autoregulation, adequate cerebral perfusion pressure, reduction of the need for carotid shunt [9, 32].

The increase in systemic blood pressure occurring after carotid clamping under RA may contribute to maintain cerebral perfusion [9].

By combining near infrared spectroscopy with continuous jugular venous oximetry, indeed, McCleary [33] demonstrated that cerebral oxygenation is maintained after carotid clamping during RA. This phenomenon is likely related to a reflex rise in blood pressure which does not occur during GA [33].

Nevertheless, RA has possible disadvantages that might offset the potential benefits of RA during carotid surgery [20, 23]. Pain and anxiety during the procedure may increase the risk of myocardial ischaemia, in spite of pre-medication, and supplement intraoperative sedation and analgesia. Short periods of deep sedation might be needed if the patient is restless or uncomfortable, particularly at the end of the procedure. It should be also considered that conversion to GA is not without risk, particularly in hurried, uncontrolled conditions. Moreover some patients, under RA, do not show immediate neurological deterioration after cross-clamping, leading to delayed shunting during an advanced state of the operation. This may result in patient exposure to borderline cerebral ischaemia for longer periods than necessary and shunt insertion under suboptimal conditions [32]. Therefore, there continues to be a need for a reliable method of cerebral monitoring in CEA even for patients scheduled for RA. Advocates of GA claim several advantages including: airway control throughout the procedure, tight control of carbon dioxide concentration, cerebral protective effects of some anaesthetic drugs, and the possibility of inducing hypothermia, if required [32].

Open issues about RA

The major request of the clinician from RA is that the right dose of the right drug is put in the right place [34].

It is widely accepted that the injection of LA with a needle positioned extra-neurally is safe and effective, whereas a needle placed into the nerve fascicle, in particular sub-perineurally, may be dangerous. Local anaesthetics at high concentrations diffuse more rapidly, thereby extending the area of block [35].

The volume of LA, providing a successful nerve block, is also debated. Recent studies indicate that peripheral nerve blocks can be performed with much lower volumes of LA than previously described [36, 37].

The idea that LA has to surround the entire nerve, the ‘doughnut sign’, to obtain a successful block has been revised and lower volumes have been shown to be equally effective, in particular if the block is performed under ultrasound guide [38].

The clinical acceptability of an anaesthetic technique is largely influenced by patient’s satisfaction, which depends either on the efficacy of the technique in pain relieving or its predictable successful outcomes, especially during CEA. The issue of patient’s satisfaction has not been thoroughly addressed in the literature [39, 40].

Recently, a prospective cohort study showed that the quality of block may considerably influence ‘patient satisfaction’, which is also related to the mood and anxiety level [41]. The surgeon and anaesthesiologist should take into account the anxiety state of the patients in planning the anaesthetic technique in this type of surgery. Moreover, satisfaction of patients undergoing CEA is influenced by the discomfort suffered during the anaesthetic block and surgical procedure. Some of open issues about RA may be solved. The block efficacy may be enhanced by associating LA with adjuvants (opioids, adrenergic agents). Ultrasound techniques, despite limited evidence in this area, may raise the standard and safety rates of the procedure, and may eliminate some causes of discomfort and improve patients’ satisfaction. The efficiency and safety of the technique mostly depend upon the training, experience, and skills of the operator. A third option may be a combination of RA with GA.

Adjuvants

The block efficacy may be enhanced by associating LA with adjuvants (opioids, adrenergic agents). Opioids and alpha-2 receptor agonists act as neuraxial adjuvants and improve the perioperative and postoperative analgesia. Recently, Danelli demonstrated that clonidine 50 µg added to ropivacaine 0.75 %, 20 mL, reduces the onset time and improves intraoperative efficacy of SCPB, thus reducing the need for lidocaine and fentanyl supplements during CEA [42].

Clonidine also induces direct peripheral effects on action potentials of nerve fibres, thus potentiating the effect of LA solutions. This effect is particularly evident when clonidine is added to intermediate or long-acting LA during single-shot peripheral nerve or plexus blocks, as the duration of analgesia and motor block may be prolonged by 2 h [43].

Clonidine, at difference from epinephrine, does not cause tachycardia and also blunts the adrenergic response, during CEA, without impairing the clinical and neurological monitoring [44].

In recent trial, fentanyl, added to local anaesthetics, has been shown to improve the quality and prolong the duration of cervical plexus block in patients undergoing CEA [45].

Ultrasonography

Ultrasound-guided regional anaesthesia is rapidly expanding. Anaesthesiologists are becoming aware of the importance of an anatomically guided approach to major nerve blocks and anaesthetic procedures [46]. Ultrasonographic techniques offer major advantages over traditional techniques for nerve localisation based on landmarks and nerve stimulation. The main advantages of ultrasound techniques applied to regional block include a direct view of nerves and adjacent anatomical structures, a close observation of the needle and LA spreading during injection, detection of anatomical abnormalities, reduced volume of LA, painless performance of blocks, and greater patient’s satisfaction [47]. Multiple ultrasound systems are available, specifically designed for RA. An ultrasound machine equipped with a high-resolution linear probe 9–5 MHz or a linear probe 6–13 MHz is used to perform DCPB and SCPB, respectively. Thus, the choice of the probe depends on the type of cervical plexus block to be performed. The needle is advanced, using an out-of plane technique for DCPB or in-plane technique for superficial cervical SCPB [48, 49].

No studies, about the use of ultrasound technique for DCPB, in CEA, have been performed. Ultrasound techniques, in case of DCPB, may allow a reduction of complications (injection of local anaesthetic into the vertebral artery, intrathecal injection, and respiratory failure/distress) due to the entrapment of the LA in paravertebral space and in direct spread of the anaesthetic injection around the cervical nerve plexus [48].

Some authors have investigated the potential advantages of ultrasonography in DCPB [48, 50–52].

Ultrasound identification of the cervical paravertebral space is very important for DCPB. There have been some studies that describe the ultrasound anatomy of the cervical paravertebral space, where cervical nerve plexus is located [53, 54]. The cervical paravertebral space is located at the posterior triangle of the neck that is formed by cervical prevertebral fascia, the paravertebral muscles and the cervical vertebra [55].

So ultrasound imaging can clearly depict both the cervical transverse processes as well as the space between the deep cervical fascia and the transverse processes; the latter can possibly be used as ‘imaging’ landmark for the injection of local anaesthetic in the cervical region [55].

Moreover, the identification of anatomical relations between the vertebral artery and surrounding structures

may facilitate the placement of the needle at the transverse processes and prevent inadvertent vertebral artery puncture during DCPB [55].

Vertebral artery lies close to C₂, C₃ and C₄ spinal nerves, and may be used as an ultrasonic landmark for identifying the deep cervical plexus. Vertebral artery, at the level of the first cervical vertebra winds behind its lateral mass and enters the skull through the foramen magnum.

A consistent but rarely mentioned feature of the vertebral artery is the prominent loop made by the artery between the first and second cervical vertebra, which allows the artery to pass from the foramen in the axis to the laterally placed foramen in the atlas. The loop can be easily identified by ultrasounds and represents an accurate landmark for C₂ transverse process and C₂ spinal nerve, placed immediately below and behind the artery, as shown by anatomical study of Sandeman [50]. This point is particularly vulnerable for inadvertent injections into the vertebral artery. The C₃ and C₄ spinal nerves exit the gutter of transverse processes slightly posteriorly to the vertebral artery. At this point, the artery is also shielded from needle puncture by bony transverse process. Vertebral artery injection is therefore virtually impossible during the block of C₃ and C₄ spinal nerves if the needle is positioned immediately above the transverse process. Identification of the vertebral artery position by ultrasonographic techniques may prevent inadvertent injections of anaesthetics into the vertebral artery as well as into adjacent structures such as radicular arteries and dural cuff. DCPB may be performed under the guide of high-resolution 9–5 MHz linear transducer which provides images of structures at depth of 3–5 cm. The technique provides satisfactory images of the vertebral artery, even in obese patients in whom traditional landmarks for the DCPB can be hardly palpated. First, Sandeman described ultrasound technique for DCPB. During DCPB, the patient lies supine, with the head turned away from the surgical area [50]. The ultrasound probe protected by a sterile cover is placed along the line joining the mastoid process and Chassaignac's tubercle. Starting from the mastoid process, the probe is moved caudally until the vertebral artery loop is visualised. Under ultrasound guidance, a 50-mm needle is advanced until the transverse process is reached: after a negative aspiration, LA may be injected. The operator keeps moving the probe caudally until a cross-sectional view of the vertebral artery is obtained between the C₂ and C₃ transverse processes. As the probe is further moved caudally, the cross-sectional view is lost at the level of C₃ transverse process. This indicates the injection point for C₃ spinal nerve. Similarly, the C₄ spinal nerve is blocked over the C₄ transverse process. The ultrasound technique provides major advantages over the classical palpation method for localisation of anatomical sites. First, the needle is positioned in the anteroposterior direction along the vertebral artery from C₂ to C₄

transverse foramina. Second, the loop of vertebral artery above the C₂ vertebral body and the loss of cross-sectional images at C₃ and C₄ provide the craniocaudal position for needle placement. Finally, the ultrasound-guided needle is placed onto C₂ transverse process, thus avoiding inadvertent arterial injections [50].

An alternative ultrasound-guided technique for DCPB has been proposed by an anatomical study that identified the anatomical basis of cervical plexus block by showing that cervical plexus is located in the groove between the longus capitis and scalenus medius [51]. The longus capitis is identified as a landmark. The deep cervical plexus, indeed, is located dorsolaterally, in the groove between longus capitis and scalenus medius, whilst the sympathetic trunk is located anteromedially on the surface of longus capitis. The ultrasound guide allows to perform a selective block of cervical plexus and cervical sympathetic trunk by injecting the LA into the longus capitis [51]. The ultrasound-guided block of deep cervical plexus and cervical sympathetic trunk may control the pain caused by dissection around and within the carotid sheath: the more frequent cause of patient discomfort during surgery.

The anatomical study of Usui [51] differs from ultrasound-guided technique for cervical plexus block proposed by Roessel [56] and based on the report by Winnie [14]. Roessel [56] performed an ultrasound-guided interscalene plexus block at upper margin of the interscalenic groove, as previously described by Merle [22]. First the author used a 17.5 MHz device that allowed a clear depiction of the target tissue, the needle placement, the LA spread [56].

Saranteas [48] described a simple method for blocking deep cervical plexus, based on their previous anatomical study [55]. The author, exploiting the fact that the cervical plexus runs in the cervical paravertebral space, easily identified, in the coronal plane, as landmarks, the sternocleidomastoid, the prevertebral fascia and the cervical transverse processes, and advanced a 24-gauge needle, using the out-of plane technique, through the prevertebral fascia [48]. The point of injection is localised between the prevertebral fascia and cervical processes.

The superficial cervical plexus can also be scanned and anaesthetised between the sternocleidomastoid and scalene muscles, using the ultrasonographic technique to identify inter-muscular planes, as previously demonstrated [57].

In a prospective, randomised, observer-blinded study, Tran compared, ultrasound-guided and traditional technique to block the superficial cervical plexus [49].

Using an ultrasound device with a 6–13 MHz linear probe, the midpoint of the sternocleidomastoid muscle was scanned in a coronal section to reveal the inter-muscular plane between the sternocleidomastoid and scalene muscles. Although neural structures (hypoechoic nodules) could be often visualised, they were not systematically

searched by the authors, because the technique relied on injection of LA in the inter-muscular plane. Nevertheless, the success rate of both traditional and ultrasonographic technique was similar, without any difference in onset and total anaesthesia-related times.

Choquet is actually using an original technique based on ultrasound-guided intermediate cervical plexus block (ICPB). In brief, the needle is advanced in plane at C₄ level between the anterior border of elevator scapulae muscle and the posterior border of sternocleidomastoid muscle to reach the posterior cervical space in which the anaesthetic solution is injected [58].

Recently, Martusevicious, showed in an observational study, the effectiveness of ultrasonography in performing the ICPB for CEA. In this study, at the level of the base of the carotid bifurcation, the needle was inserted, at the lateral border of the sternocleidomastoid muscle, and, guided by ultrasound, advanced 0.5–1 cm posterolateral to the carotid artery, where ropivacaine (7.5 mg ml⁻¹) was injected [59]. During retraction of the needle, additional local anaesthetic was administered beneath the sternocleidomastoid muscle and, finally, subcutaneous infiltration along the surgical incision line was performed. Similar to Martusevicious, Rössel has performed high-resolution ultrasound-guided regional anaesthesia using a 12.5 MHz linear ultrasound transducer in 34 patients undergoing CEA [60]. Anaesthesia consisted of perivascular anaesthesia of the internal carotid artery and ICPB. Both studies showed a lower supplement of local anaesthetic and a lower incidence of intraoperative complications.

Third option: regional combined with general anaesthesia

This technique may provide major advantages in patients undergoing CEA, particularly in subjects unsuitable for regional techniques alone because of unstable cardiovascular or respiratory conditions, anxiety. Available short-acting general anaesthetics maintain stable intraoperative hemodynamic parameters, and allow a rapid recovery for an immediate neurological evaluation; local anaesthesia also provides a good postoperative pain relief. In a trial of 2007, by combining the superficial cervical plexus block with general anaesthesia, it has been clarified that the procedure is effective in reducing morphine doses and improving pain relief after carotid endarterectomy [61].

As for cardiovascular stability, after CEA, investigators obtained remarkable beneficial effects by combining general anaesthesia with superficial cervical block and the intraoperative administration of clonidine [62].

Recently, a new technique of combined regional and general anaesthesia has been introduced. The procedure

allows a strict monitoring of neurological functions during carotid clamping by reducing the hypnotic component of anaesthesia but preserving the analgesic one. The “wake up test”, as previously defined in neurosurgical procedures, [63–65] was used, during CEA, first by Baldinelli [66]. Precursors of the above described technique are the conscious sedation techniques which use opiates drugs alone or associated with hypnotic drugs [67, 68].

The combined regional and general anaesthetic technique shares with RA the advantages of continuous clinical monitoring of patient and, with GA, optimal airways control via the trachea intubation. The first pilot study, performed by Luchetti, showed that SCPB associated with continuous intravenous infusion of remifentanyl and propofol in intubated patients, guaranteed more stable hemodynamic conditions, better patient comfort and more effective analgesia as compared to SCPB alone during elective CEA [69]. Bevilacqua, in a prospective study enrolling 181 consecutive patients, used a similar Luchetti technique defined “Cooperative Patient General Anaesthesia” (Co.PA.Ge.A.). This technique included a local infiltration of ropivacaine 1 % 10 ml in the anterior border of sternocleidomastoid muscle, instead of SCPB [70].

Remifentanyl-based technique, applied in both studies, has been demonstrated to be safe and to have a low rate of conversion to general anaesthesia. A continuous monitoring of neurological conditions, during carotid clamping, allows to detect early signs of cerebral hypoperfusion and a prompt and safe conversion to GA, in particular when neurological symptoms are not reversed by carotid shunt.

Future directions

No definitive results about the efficacy of ultrasonography in the cervical plexus block are available, as the interpretation of some ultrasound images is still controversial, due to several reasons such as differences in scanning method, block techniques (deep, superficial, intermediate), lack of well-designed clinical studies [58]. Anatomical variation, as well as pathological distortion of anatomy, can provide a challenge to the examiner when interpreting the appearance of a sonogram. The anaesthesiologist should perform a scan of the perineural region and appropriately interpret any abnormal appearance, before performing an ultrasound-guided nerve block [71]. Recently, Narouze outlined the need of accurate identification of the correct level [72]. The cervical transverse process may be identified in the short-axis view or long axis. The in-plane or out-of-plane approach can be used with either technique [72].

The advantages of the long-axis view are the lower risk of miscounting the cervical level, having more than one

cervical level, and the better identification of the nerves that appear in a cross-section as an oval structure, with the typical sonographic appearance of a small peripheral nerve. On the other hand, the short-axis view offers better visualisation of critical blood vessels. Two-dimensional (2D) ultrasound technology captures a planar image. Three-dimensional (3D) ultrasound image will become a valid alternative to 2D ultrasound technology. This, showing multiple planes of view simultaneously, can provide information of the entire anatomic region including 360° spatial relationships of adjacent structures. Further, 2D ultrasound technology only provides a “doughnut” sign of spread of local anaesthesia in one plane in contrast to 3D imaging which will provide 360° data set on the distribution of the local anaesthesia around the nerves [73].

Advantages of 3D ultrasound may include the ability to monitor correct needle placement and spread of local anaesthetic along the nerve and better identify adjacent unwanted targets (pleura and blood vessels). A recent editorial proposed questions on the ideal pattern of LA spread for a safe and effective block and 3D ultrasound may be a tool in the future for this research [74].

Conclusions

Regional anaesthesia for CEA is an important anaesthetic option, which allows a strict monitoring of cerebral perfusion and an effective protection of brain during carotid cross-clamping. The gold standard for RA (high quality and safety) will be achieved after overcoming a number of limitations (patient discomfort, insufficient block, inadvertent vertebral artery puncture), by a more extensive use of ultrasonography, by combining general and regional anaesthesia, including conscious anaesthesia, by defining the appropriate volume, concentration and dosage of local agents and by addition of adjuvants. After the gold standard has been achieved, the best anaesthetic technique should be selected on individual basis.

Conflict of interest Alessandra Ciccozzi, Chiara Angeletti, Cristiana Guetti, Joseph Pergolizzi, Paolo Matteo Angeletti, Roberta Mariani Franco Marinangeli declare that they have no conflict of interest.

Human and animal studies The study described in this article does not contain studies with human or animal subjects performed by any of the authors.

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