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Local Anaesthetic Technique in Endovascular Abdominal Aortic Aneurysm Repair: Is it Time to Change the Paradigm?

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Abstract

Endovascular repair of abdominal aortic aneurysm has been the main treatment approach for the last two decades. Its outcomes have been reported to be satisfactory over such period and provided a lower morbidity and mortality rates when compared to the conventional open repairs. With time, the initial use of general anaesthetics has been replaced with regional anaesthesia and lately, the utilization of local anaesthesia (LA) for stenting the abdominal aortic aneurysms have been practiced in several centres internationally with excellent outcomes in selected cohorts. The key success in using LA is the advancement in the access techniques and less requirement for conventional open method to advance and deploy the stents through the femoral artery. This literature review aims at examining the current evidences behind the success of LA and whether it is going to be the new wide spread and standard method for anaesthesia in elective or emergency cases of endovascular repair of abdominal aortic aneurysms.

Keywords: Local anaesthesia; General anaesthesia; EVAR; Endovascular; Aneurysm repair

Introduction

Abdominal aortic aneurysms (AAA) is defined as 'an enlargement of the aorta of at least 1.5 times its normal diameter or greater than 3 cm diameter in total' [1]. Risk factors include male sex, increasing age, hypertension, smoking and family history of AAA. AAA is becoming increasingly common in our ageing population, with up to 12.7% of UK population may be affected [1]. Many will continue to grow and remain asymptomatic until rupture. Rupture AAA carries a high mortality rate ranging from 80% to 90% [1,2]. While traditionally treated with open repairs (OR), the introduction of EVAR by Volodos and Parodi in 1991 has led to improved surgical outcomes for many patients [3]. Although it is recognised that a benefit of EVAR is the reduced time under general anaesthesia (GA), most of the research since then was focused on efficacy of EVAR; not many has considered the safety and impact of anaesthetic choices in these patients [1].

Traditionally, EVAR is performed under GA but recent studies have observed advantages in using local anaesthesia (LA) [4-6]. AAA, especially when ruptured, creates a fragile haemodynamic state which can be exacerbated by the choice of anaesthesia. During rupture, the patients are hemodynamically unstable, with hypovolaemia and there is under-perfusion of body organs. The use of GA may lead to exacerbation of haemodynamic collapse due to changes in mean arterial blood pressure (MAP) and heart rate. Recent research in vascular surgery, by Glaser et al. has identified GA as an independent predictor of increased hospital stay with an OR of 2.6 (CI [1.3-5.0]; $P<0.01$) for patients who had carotid endarterectomy [7]. Another study on vascular surgery identified general anaesthesia as a variable for increased complications and mortality, with an OR of 1.50 (CI [1.20, 1.86]; $P < 0.05$) [8]. While there is yet to be a consensus the optimal anaesthesia, there is evidence to warrant a comparison against LA as an option for EVAR. This review will assess whether current literature can provide enough evidence to support the use of LA across different EVAR settings.

Anaesthetic Technique

General anaesthesia

The use of GA requires consulting an anaesthesiologist and performing a preoperative assessment of ASA grade, anticipated difficulties with airway and glycemic control. A review on EVAR found the most commonly used GA agents included propofol, thiopental, midazolam and etomidate [9]. Since intubation is needed in GA, muscle relaxants such as rocuronium, cisatracurium, vecuronium, pancuronium were used to suppress laryngospasm and reduce movements during operation. Post-operative nausea and vomiting can be prevented using 5-HT3 antagonist like ondansetron. In order to maintain sedation, gaseous anaesthetics such as sevoflurane and isoflurane were given. Analgesic such as fentanyl and remifentanil were used to minimise peri-operative and postoperative pain. After completion of the EVAR procedure, agents such as neostigmine, atropine and sugammadex were used to reverse the effects of anaesthesia.

Local anaesthesia

LA technique involves local infiltration of adrenaline with either lidocaine or bupivacaine into the groin to provide pain relief during the access of femoral artery for EVAR. Occasionally, additional bolus dose of fentanyl can be given for any intolerance that is caused initially.

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Sedation with anxiolytics, such as bromazepam or midazolam, may be required if patients expressed signs of anxiety. Strong opiates, including fentanyl and sufentanil, can also be given intravenously to induce sedation while the procedure is carried out.

Anaesthetics techniques in elective EVAR

Elective EVAR is recommended in unruptured abdominal aortic aneurysms (AAA) that is of 5.5 cm or more in diameter or if the aneurysm is 4.5 cm or more in diameter with a growth rate of more than 0.5 cm over 6 months [1].

Traditionally, such elective cases were performed under general anaesthetics (GA), however with advancement in anaesthetic and surgical practices, this practice has evolved to different measures. The regimes used in general anaesthetics for elective EVAR vary between studies. Yağan et al suggested a combination of propofol or thiopental and rocuronium for induction, sevoflurane for maintenance and neostigmine/atropine/sugammadex for reversal [4]. On the other hand, Ruppert et al did not specify any GA techniques [3]. Local anaesthetic technique is defined as using lidocaine or bupivacaine infiltration to the groin to allow access to the femoral artery for access and stent deployment thereafter [6].

A study by Edwards et al. identified 6,009 elective EVAR procedures performed between 2005-2008; among the cohort only 4,868 (81%) cases were performed utilizing GA while the rest (19%) were performed under loco-regional anaesthesia [10]. The authors concluded that GA was associated with higher pulmonary morbidity (OR, 2.6; CI [1.0, 6.4], P = 0.04) and longer length of stay (OR 20.0; CI [14.1%, 26.2%]; P < 0.001) [10]. However, the key issue in the analysis was the small sample size of the solo local anaesthetic cases (n=391), thus creating a bias in the analysis and the reported outcomes.

In a separate retrospective analysis based on EUROSTAR dataset by Ruppert et al. that compared 3 groups of patients with infrarenal aortic aneurysm requiring intervention; 3848 GA, 1399 regional anaesthetics (RA) and 310 LA cases [3]. Comparison between GA and LA found no significant reductions in intraoperative complication such as device related complication (5.1% *vs* 3.6%, P>0.05), failure to complete procedure (1.7% *vs* 1.0%, P>0.05) and arterial complications (3.8% *vs* 2.0%, P>0.05). However, systemic complications were seen more frequently in GA than LA (13% *vs* 6.6%, P = 0.0015). Additionally, in a study by Broos et al.; they compared different anaesthetic techniques using data retrieved from Endurant Stent Graft Natural Selection Global Post-Market Registry (ENGAGE) database [5]. The prospective, multicentre and non-randomised registry assessed the Endurant Stent Graft System. There was a total of 785 cases performed under GA and 331 cases under LA cases. The LA group had a shorter procedure time (80.4 ± 40.0 minutes) compared to GA (105.3 ± 46.0 minutes, adjusted P <0.001). GA patients stayed in the hospital significantly longer than LA patients (5.2±5.4 *vs* 4.0±3.6, P = 0.010). All-cause 30-day mortality rates were no different between GA and LA cohorts (OR 0.91; CI [0.19, 4.36], P = 0.90). The authors noted LA cases used a significantly higher quantity of contrast (148.4 ± 71.9 *vs* 130.9 ± 71.2, P = 0.028), this may be due to optimization of image quality as it is dependent on patient's movements and ability of breath holding during imaging. In addition, since contrasts are often nephrotoxic, it is worth considering patient's kidney function when considering using LA for EVAR. In all these reported studies, the choice of anaesthetic technique was not rationalized but rather was surgeon and anaesthetist preference, therefore the results need to be interpreted carefully.

In contrast to the observed benefits of previous studies, a single-centre retrospective cohort study in Korea observed no significant benefits when examining 144 GA and 115 LA cases [6]. The study compared 30-day clinical outcome including length of stay (LOS), post-implantation syndrome (PIS), 30-day morbidity, mortality and secondary therapeutic procedures. Risk factors and patient demographic data including ASA grade, smoking, heart diseases were also considered. During EVAR, anatomical data of the AAA were collected, and the only difference is that LA was more frequently used in patient with AAA extending to the common iliac artery (27.1% *vs* 39.1%; P=0.040). Furthermore, although there were higher rates of endoleaks in the GA cohort at immediate post-procedure and 30-days, but this didn't reach statistical significance (14.1% *vs* 18.4%; P=.347; and 23.6% *vs* 19.1%; P=.384 respectively). Table 1 is summary of the key studies of using LA *vs* GA in elective EVAR.

In conclusion, there are not enough large-scale studies so far to confirm the superiority of either techniques in terms of postoperative outcomes. Studies have shown that GA is known to be better in using less contrast during the procedure and it is till the universal method. However, small studies suggest that LA are better in reducing hospital stay, less systemic complications and lower risk of endoleaks [3,5,6]. The sample size of LA cases is often disproportionately smaller when comparing to GA cases. This is partly due to most EVAR are still performed under GA despite US guidelines from Society for Vascular Surgery recommended the use of LA [11]. In contrast, the European Vascular Surgery and UK NICE guidelines are not explicit regarding type of anaesthesia [1,12].

Anaesthetic Techniques in Emergency EVAR

While many abdominal aortic aneurysms develop unnoticed, they may vary in size and has rupture rates ranging from 1% to 22% [13]. When patients develop ruptured abdominal aortic aneurysms (rAAA), mortality reaches 90% and more than half of rAAA die prior to arrival to hospital or gets appropriate intervention [2]. The Society for

Author	Year	Country	Type of Study	Total cohort	RA (n)	LA (n)	GA (n)	Primary End Points
Edwards et al. [10]	2005-2008	US	Retrospective analysis	6009	750	391	4868	GA for EVAR was associated with increased postoperative LOS and pulmonary morbidity compared with spinal and local/MAC anesthesia.
Ruppert et al. [3]	1997-2001	EUROSTAR	Retrospective	5557	1399	310	3848	LA & RA enhanced perioperative advantage
Broos et al. [5]	2009-2011	International	Retrospective analysis	1261	331	145	785	LOS was significantly shorter for RA and LA compared with GA. No significant differences in systemic and surgical complications. Mortality rates within 30 days did not differ among the groups.
Noh et al. [6]	2011-2016	Korea	Retrospective observational	276	0	115	144	No definite evidence that the anesthesia techniques affect length of hospital stay or 30-day clinical outcomes.

LA= Local anaesthesia, GA=General anaesthesia, RA= regional anaesthesia, LOS=length of stay

Table 1: Summary of key studies for elective EVAR.

Vascular Surgery AAA guidelines recommend a <90-minute door-to-intervention time from were patients should be evaluated, diagnosed, stabilised, transferred if needed and appropriate intervention carried out [11,14].

EVAR is commonly used to treat rAAA as it offers improved perioperative outcomes such as over 50% reductions in blood losses as well as lowering mortality from 50% to as low as 15% compared to open repairs [15-17]. The preoperative stage involves the surgeon and radiologist to determine if the aortic morphology is suitable for EVAR via computerised tomography (CT) [15]. The surgical step begins with cannulating femoral vessels and to insert an aortic stent under local or general anaesthesia [15]. Then the procedure itself can then begin under local or general anaesthesia.

The concerns with anaesthesia during rAAA intervention arise with haemodynamic collapse which can be through cardio depressant effects, worsening of intra-abdominal bleeding, and reductions in venous return, sympathetic tone as well as tamponade effect [18,19]. With the lack of formal and rigorous guidelines and level 1a evidence to examine anaesthesia choices in emergency EVAR, many clinicians resort to their own experiences and preferences.

The choice for anaesthesia for emergency EVAR varies between regions and centers; LA use from UK and Canadian data ranges between 38% and 78% whereas US is between 9% and 12% [9,18,20-22]. GA is generally used for practical benefits such as easier blood pressure control, better breath-holding for imaging as well as easier stent placement [6]. While generally GA is used more, in some instances patients who opted for LA in the first place were required to convert to GA, reasons including intolerance, ventilatory compromises and cardiovascular instability [5,11]. There is a trend to increase using LA in emergency EVAR as various studies have identified possible benefits, such as avoiding circulatory collapse and reducing both mortality and postoperative complications [23,24]. However, these observed benefits are not yet fully substantiated due to various limitations of these studies.

Mouton et al. performed a retrospective study on rAAA with 319 and 435 patients undergoing LA and GA respectively [22]. Using Kaplan-Meier curves, they estimated a lower 30-day mortality rate in LA cohort (34% *vs* 39.5%). While the validity of National Vascular Registry database is high, with 90% case ascertainment, the results are limited by the lack of details, especially on sedation and conversion of LA to GA. Combined with the lack of clear distinction between sedation and GA, bias may be introduced, and interpretation should be taken in the context.

El-Hag et al. performed a retrospective analysis of 1244 rAAA cases treated by EVAR, from National Surgical Quality Improvement Programme (NSQIP) dataset, saw a significant improvement in cumulative incidence of 30-day mortality in LA compared to GA (AHR, 0.49; cumulative incidence, 10.3% *vs* 24.1%; P = 0.012) [25]. Furthermore, they identified that the use of LA in low risk patients provided a significant decrease in mortality rates, 1.2% compared to 15.4%, against GA (P = 0.018). However, high risk patients do not seem to experience a significant benefit, having 30.6% for LA and 38.8% for GA (CI [0.48, 1.48]; P = 0.56) [25]. El-Hag et al. performed similar analysis on 1144 patients from Vascular Quality Initiative (VQI) database, and also reported significant benefits in 30-day mortality rates of 16.5% in LA and 24.3% in GA (AHR, 0.65; P = 0.045). 1-year mortality rates were also analyzed to show 25% and 33% in LA and GA respectively (AHR 0.7; P = 0.048) [20]. Greater benefits were also seen in lower mortality risk group, specifically those with one or less risk factors among >75 years old and lowest preoperative systolic blood pressure (LPSBP) <90 mm Hg. Both studies were limited by the relatively small LA sample size in comparison with the GA sample.

Similarly, a multi-centre randomised controlled trial by IMPROVE was conducted to compare survival benefits between EVAR and OR for rAAA. The dataset also included supplementary data on anaesthesia and allowed them to identify a significant four-fold survival benefit of using local anaesthesia when compared to general anaesthesia [21]. There is a significantly reduced 30-day mortality (adjusted OR 0.27; CI [0.10, 0.70]; P = 0.007) compared to GA group [21]. However, as their study was only randomised for comparison between EVAR and OR, not all factors specific to anaesthesia may have been accounted for; their primary adjustments included only age, sex, maximum aortic diameter and Hardman index. In addition, the study must be interpreted with care as their data was obtained from an emergency setting and did not always include non-essential details, such as type of anaesthesia as well as fluid administration, which may have required adjustment. Mayer et al. also produced a similar analysis and concurs with the IMPROVE study with a large improvement in 30-day mortality of 16% in LA compared to 58% in GA [26]. The biggest limitation of these studies was the small sample size of under 300 in IMPROVE and the two retrospective studies by Mayer et al., which could account for any significant benefit compared to studies with larger samples [26,27].

For many surgeons and anaesthetists, the rationale for choosing particular anaesthesia remains unclear and does not seem to be affected by parameters such as ASA grade, CV risk factors or aortic diameter [22]. It should also be noted that many experienced clinicians prefer the use of local over general anaesthesia [21,26,27]. Overall, despite the lack of large-scale clinical trials to confirm the benefits of local anaesthesia in emergency EVAR, there is enough evidence to warrant one and substantiate the interpretations. Table 2 is summary of the key studies of using LA *vs* GA in emergency EVAR.

Complex EVAR and Use of Local Anaesthesia

Complex EVAR is performed on upper abdominal aneurysms, such as juxta-renal and thoracoabdominal, that extends to involve branches [28]. Similar to emergency EVAR, much of literature on anaesthesia choice are retrospective studies and highlights the need for RCTs to draw strong conclusions. Currently, there are limited data on using LA in EVAR during complex aneurysm repairs and this is mainly due to multi-segment involvement of the thoraco-abdominal aorta.

A meta-analysis by Karthikesalingam et al. examined 13,000 patients across ten studies to concluded that reduced complication rates in LA and RA are likely due to biases in patient selection [29]. Instead of anaesthetic technique, the observed differences in morbidity may have stemmed from the difference in patient comorbidities, such as those with complex AAA and presence of obesity [1,4]. While AAA morphology is likely to be an important factor in determining surgical outcome, very few studies have included both morphological information and anaesthetic information, allowing room for bias. Moreover, to date, there is no solid literature evidence that directly and comprehensively compares the use of LA and GA within complex EVAR cohorts at large scale; but rather the data are limited to small case series and single centre experiences.

EUROSTAR dataset was the only study that included basic clinical information, anaesthesia type, device type as well as various aneurysm dimensions [3,30]. The study reported no significant differences in aneurysm diameter, neck length and neck diameter across LA and GA

Author	Year	Country	Type of Study	Total cohort	RA (n)	LA (n)	GA (n)	Primary End Points
El-Hag et al. [25]	2009-2014	US	Retrospective analysis- NSQIP	1244	0	117	1127	Use of LA has significantly reduced mortality rates in patients with lower surgical risks.
El-Hag et al. [20]	2003-2015	US	Retrospective analysis- VQI	1144	0	140	1004	Use of LA is associated with lower morbidity, 30-day and 12-month mortality rates. Greatest mortality benefits seen in low surgical risk patients.
Mouton et al. [22]	2014-2016	UK	Retrospective analysis -The UK National Vascular Registry	795	41	319	435	Use of LA associated with reduced mortality compared to GA.
Powell et al. [21]	2013	UK, Canada	Randomised controlled trial- multicentre	182	0	69	113*	Using LA associated with a fourfold survival benefit (adjusted) over GA
Mayer et al. [27]	1998-2008	Switzerland	Retrospective analysis	102	0	71	31*	No significant differences between both cohorts

LA= Local anaesthesia, GA=General anaesthesia, RA= regional anaesthesia
*GA figures include conversions from LA to GA

Table 2: Summary of key studies for Emergency EVAR.

groups [30]. Despite the included data, a distinction between normal EVAR and complex EVAR cannot be made as aneurysm dimensions do not translate to complex aneurysms where visceral branches are affected. However, they were able to identify that while only 6% of EVAR was done using LA, there may be a selection bias for low risk patients and less complex aneurysms which may affect outcome if unadjusted [3,30]. This highlights the need to identify and account for factors, such as morphology, when investigating the effects of anaesthesia choice within complex EVAR [3,30].

Is Local Anaesthesia Taking over the General Anaesthesia Technique

Despite the lack of data from randomised control trials to support the use of LA in EVAR, data from multiple observational studies showed relatively similar benefits over GA. General anaesthesia use in elective EVAR was associated with higher postoperative complications and longer hospital stays but there were no significant differences in mortality and intraoperative complications. However, reductions in 30-day mortality was seen in emergency EVAR, especially in those considered low surgical risk. Current literature does not allow effective comparison of complex EVAR as most studies do not include morphological data.

All-in-all, more must be done to substantiate and quantify the observed benefits in using LA in EVAR. A large randomised control trial could provide high quality evidence while future observational analyses would benefit from increased recording of supplementary data in current studies.

Conclusion

There is a steep learning curve in utilising local anaesthesia for EVAR as it requires selected anatomical considerations and surgeon experience. However, the use of local anaesthesia, where feasible, provides satisfactory and comparable outcomes in patients undergoing EVAR. The choice of this technique should be encouraged in selected patients.

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