

REVIEW ARTICLE



## Superficial or deep cervical plexus block for carotid endarterectomy: a systematic review of complications<sup>†</sup>

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Carotid endarterectomy is commonly conducted under regional (deep, superficial, intermediate, or combined) cervical plexus block, but it is not known if complication rates differ. We conducted a systematic review of published papers to assess the complication rate associated with superficial (or intermediate) and deep (or combined deep plus superficial/intermediate). The null hypothesis was that complication rates were equal. Complications of interest were: (1) serious complications related to the placement of block, (2) incidence of conversion to general anaesthesia, and (3) serious systemic complications of the surgical-anaesthetic process. We retrieved 69 papers describing a total of 7558 deep/combined blocks and 2533 superficial/intermediate blocks. Deep/combined block was associated with a higher serious complication rate related to the injecting needle when compared with the superficial/intermediate block (odds ratio 2.13,  $P=0.006$ ). The conversion rate to general anaesthesia was also higher with deep/combined block (odds ratio 5.15,  $P<0.0001$ ), but there was an equivalent incidence of other systemic serious complications (odds ratio 1.13,  $P=0.273$ ; NS). We conclude that superficial/intermediate block is safer than any method that employs a deep injection. The higher rate of conversion to general anaesthesia with the deep/combined block may have been influenced by the higher incidence of direct complications, but may also suggest that the superficial/combined block provides better analgesia during surgery.

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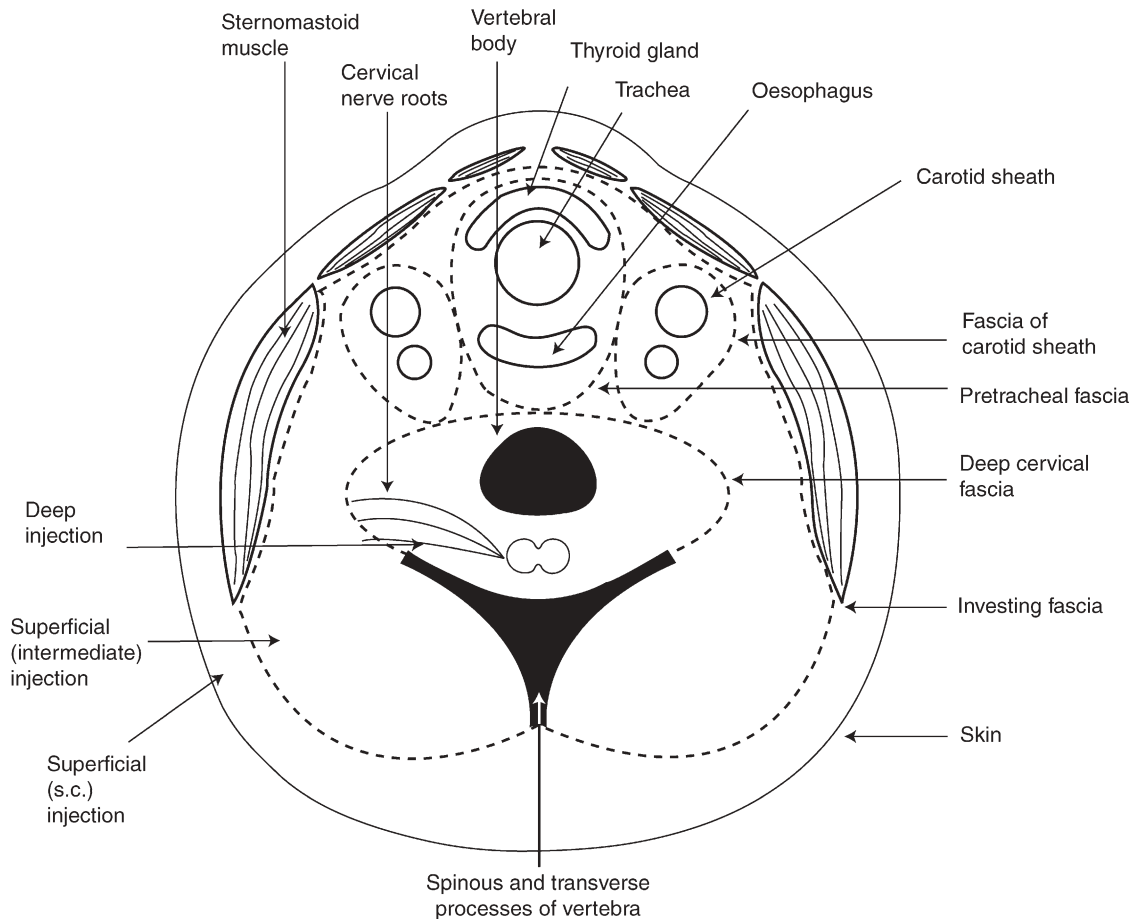
Carotid endarterectomy surgery is commonly performed under cervical plexus block.<sup>79–81</sup> This is presumed to offer advantages over general anaesthesia in terms of monitoring neurological function during cross-clamping of the carotid artery since, in conscious patients, speech, cerebra- tion, and motor power provide early measures of inadequate cerebral perfusion.<sup>2–7</sup> Some studies also claim lower shunting requirements, lower cardiovascular morbidity, and shorter hospital stay.<sup>9–67</sup>

Traditionally, the common methods of cervical plexus block are termed ‘deep’ or ‘superficial’. The deep block, as described by Moore<sup>74</sup> or Winnie and colleagues,<sup>111</sup> consists of identifying the transverse processes of upper cervical vertebrae C2–C4 and injecting local anaesthetic directly into the deep (prevertebral) cervical space. This may be achieved either as three separate injections or as a single injection. The superficial block incorporates a variety of procedures. The simplest is a s.c. infiltration of

local anaesthetic along the posterior border of sternocleidomastoid muscle by either the surgeon or the anaesthetist.<sup>92</sup> An ‘intermediate’ block is one where the injecting needle pierces the investing fascia of the neck, deep to the s.c. layer, but superficial to the deep cervical (prevertebral) fascia (Fig. 1).<sup>78–80</sup> It is also possible to use a ‘combined block’, consisting of a deep injection and a superficial or intermediate injection.<sup>79</sup>

Practitioners may prefer one block to another, but no consensus exists on the efficacy of one block when compared with another. However, it has been suggested that complications of the technique are related to the deep injection and not the superficial (or intermediate) injection.<sup>81</sup> These complications include intrathecal or

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**Fig 1** Drawing of a cross-section of the neck at the C4 vertebral level, showing the sites of injection of the deep, intermediate, and superficial blocks (adapted from Pandit and colleagues<sup>80</sup>).

intravascular injection, respiratory problems related to phrenic nerve paralysis, or local anaesthetic toxicity. Nonetheless, after recently describing two complications using the deep cervical plexus block, Carling and Simmonds<sup>18</sup> stated explicitly that ‘the safest cervical block has not yet been established’, so the issue is one which indeed warrants more definitive evidence.

The aim of this review was to compare the incidence of complications associated with the use of a deep injection, whether as a sole technique or as part of a combined block, with the use of superficial or intermediate injections alone. We wished to investigate this question using quantitative methods to retrieve and analyse the relevant published literature. The null hypothesis of our analysis was that the incidence of complications was the same with both techniques.

## Methods

We adhered to the Meta-analysis of Observational Studies in Epidemiology (MOOSE) guidelines in the conduct of this review.<sup>105</sup> We searched the electronic databases PubMed, Medline, and EMBASE from 1966 to 2005

using the phrases ‘carotid’, ‘endarterectomy’, ‘cervical’, ‘plexus’, ‘local’, ‘regional’, ‘anaesthesia’, and combinations of these phrases. We then manually searched the reference lists of any relevant published article we retrieved. We also checked the Cochrane Controlled Trials register and the Bodleian Library’s database of doctoral theses for any relevant studies.

Articles were accepted if they fulfilled the following criteria: (1) a cervical plexus block was used in at least one group of patients reported in the study; (2) the type of block used was identifiable (i.e. deep, combined, superficial, or intermediate); (3) the surgery performed was carotid endarterectomy; (4) the article stated explicitly that it sought to document complications of the procedure, or described such complications, or stated categorically that there were no complications; (5) for any complications referred to, the article explicitly described which complications occurred and with which type of block; and (6) the article stated the number of patients studied (denominator) and the number of patients with complications (a numerator). For most case reports, this last criterion was less relevant since usually, only one case was reported; that is, the denominator and numerator were the same. Articles

were rejected if they did not meet the inclusion criteria above and also if: (1) they presented duplicate data published elsewhere and (2) they were published only as abstracts.

Articles were assessed using these criteria independently by the three authors. Any disagreements over acceptance/rejection were then discussed by all three authors.

We used the following terminology to describe the blocks used. A 'deep' cervical plexus block included any technique that employed a deep injection (e.g. a deep block alone or a combined block). A 'superficial' block was any technique that relied on either superficial or intermediate injection alone.

Retrieved papers were classified into five types of study:

- (1) randomized trials comparing deep vs superficial block;
- (2) randomized trials comparing general anaesthesia and deep or superficial block;
- (3) non-randomized trials comparing general anaesthesia and deep or superficial block;
- (4) case series reporting the use of deep or superficial block;
- (5) case reports or letters describing specific complications associated with the use of deep or superficial block.

Within each of these types of study, we noted the total number of patients in each of the retrieved papers (the denominator); and we noted the following numerators as the three categories of complications.

- (a) The number of patients suffering 'block-related serious complications'. These were defined as complications which were a threat to life arising from block placement and we included: intravascular or intrathecal injection of local anaesthetic, established (or suspected) local anaesthetic toxicity (in the absence of known or suspected intravascular injection), local trauma, or haematoma caused by the injecting needle leading to cancellation of surgery, airway obstruction, or respiratory distress after placement of block but before surgery (e.g. due to established or suspected diaphragmatic or vocal cord paralysis).
- (b) The number of patients requiring 'conversion to general anaesthesia' after placement of the block for any reason. These reasons included: any block-related serious complication as defined earlier; failure of adequate analgesia (i.e. block failure); lack of patient co-operation after insertion of the block; or extreme patient anxiety. We were aware that in some centres, any central nervous system (CNS) symptoms during cross-clamping or insertion of a shunt are indications for conversion to general anaesthesia; therefore, this was also noted.
- (c) The number of 'serious systemic complications'. These included: death due to any or an unspecified cause (excluding any related to direct placement of the block) during surgery or in the immediate post-operative period; cardiovascular complications (e.g.

myocardial infarction, angina); CNS complications [cerebrovascular accident/stroke, transient ischaemic attack (TIA), unconsciousness due to any or unspecified cause, other than due to direct complication of the block]; airway or respiratory complications during or after surgery (i.e. excluding those related to placement of the block itself); and significant wound haematoma during or after surgery. We did not define a strict time interval or limit for the 'postoperative phase', since this varied between articles. Therefore, we planned to accept any complication described by the authors as 'perioperative'.

In this scheme, the 'block-related serious complication' rate was our primary end-point, and an index of the safety of the block. The rate of 'conversion to general anaesthesia' was a crude measure of the efficacy of the block. The rate of 'serious systemic complications' was a crude measure of the overall risk of the surgical-anaesthetic process. We did not expect this last measure to differ between superficial and deep block, but could not anticipate the outcome of comparison of the other two measures. With respect to randomized or non-randomized trials comparing general anaesthesia and deep or superficial block, we used only the data from the cervical plexus block groups, and excluded consideration of the data from the general anaesthesia groups.

As deep block has probably been in use for longer than superficial, we wished to examine any 'publication bias' and exclude the possibility that complications associated with deep block occurred in earlier papers. We plotted the number of papers published examining deep and superficial block by year of publication, to assess if certain epochs yielded papers for only one type of block.

For each category of complication, we summed the numerator figures and the denominator figures from each of the studies to obtain a complication rate (expressed as a proportion). Then, for categories (1) to (4), we combined these complication rates to obtain total rates separately for deep and superficial block. We assessed the significance of the difference in these complication rates between deep and superficial block using the  $\chi^2$  test (Fisher's exact test where the numerator was zero).<sup>5</sup> We also calculated the odds ratio and relative risk of deep vs superficial block<sup>6</sup> (for this purpose, the 'rule of three' was used to estimate the implication of zero numerators).<sup>33</sup> We took  $P < 0.05$  to represent statistical significance. We did not subject the complications from case reports [category (5)] to statistical analysis, but assessed these data separately and subjectively.

## Results

Our initial search retrieved 92 potentially relevant papers from 1974 to 2006. However, we excluded nine because they did not meet the inclusion criteria. Five papers lacked

a clear statement or record of complications of the technique.<sup>23 40 69 91 93</sup> Two papers did not adequately describe the block used.<sup>84 110</sup> Two papers,<sup>82 87</sup> in our judgement, contained duplication of data published elsewhere<sup>7 47</sup>—for these papers, we included in our analysis the versions of the data<sup>7 47</sup> that seemed to us the more complete.

This left 83 papers for analysis: two randomized trials of deep and superficial block [category (1)]; three randomized trials of superficial (one paper) or deep block (two papers) and general anaesthesia [category (2)]; 25 non-randomized trials of superficial (three papers) or deep block (22 papers) and general anaesthesia [category (3)];

39 case series of superficial (11 papers) or deep block (28 papers) [category (4)]; and 14 case reports.

There were only two randomized controlled studies directly comparing deep with superficial block (Table 1). There were no serious complications as a direct result of the block. However, deep block yielded one conversion to general anaesthesia (patient anxiety) and there was a single systemic complication (cerebrovascular accident) in each of the two studies.

For randomized comparisons of block with general anaesthesia (Table 1), there were no serious complications as a direct result of either block. However, deep block

**Table 1** Results for randomized controlled studies. From each paper, only the regional block limb of the study has been used. The numerator represents the number of complications in each category; the denominator represents the total number of patients in the study. The last row represents the sum of the rows above

Reference	Serious complications as a result of block		Conversion to general anaesthesia		Total serious complications	
	Superficial	Deep	Superficial	Deep	Superficial	Deep
<i>Comparing deep and superficial block</i>						
Pandit and colleagues <sup>79</sup>	0/20	0/20	0/20	0/20	0/20	1/20
Stoneham and colleagues <sup>102</sup>	0/20	0/20	0/20	1/20	0/20	1/20
Total	0/40	0/40	0/40	1/40	0/40	2/40
<i>Comparing general anaesthesia and superficial block (one study) and general anaesthesia and deep block (two studies)</i>						
Prough and colleagues <sup>85</sup>	0/13		0/13		0/13	
Forssell and colleagues <sup>38</sup>		0/56		2/56		9/56
Sbarigia and colleagues <sup>88</sup>		0/50		0/50		8/50
Total	0/13	0/106	0/13	2/106	0/13	17/106

**Table 2** Results for non-randomized controlled studies comparing general anaesthesia and superficial block (three studies) and general anaesthesia and deep block (22 studies). From each paper, only the regional block limb of the study has been used. The numerator represents the number of complications in each category; the denominator represents the total number of patients in the study. The last row represents the sum of the rows above

Reference	Serious complications as a result of block		Conversion to general anaesthesia		Total serious complications	
	Superficial	Deep	Superficial	Deep	Superficial	Deep
Gabelman and colleagues <sup>39</sup>	0/54		0/54		13/54	
McCarthy and colleagues <sup>67</sup>	0/100		0/100		7/100	
Stoughton and colleagues <sup>104</sup>	0/150		9/150		2/150	
Agrioglio and colleagues <sup>1</sup>		0/30		0/30		1/30
Allen and colleagues <sup>5</sup>		0/318		1/318		26/318
Anderson and colleagues <sup>7</sup>		0/232		23/232		11/232
Buchbinder and colleagues <sup>15</sup>		0/99		0/99		6/99
Calligaro and colleagues <sup>17</sup>		0/185		10/185		4/185
Corson and colleagues <sup>22</sup>		0/157		5/157		4/157
Eibes and colleagues <sup>30</sup>		0/69		2/69		2/69
Fiorani and colleagues <sup>36</sup>		0/683		5/683		21/683
Forssell and colleagues <sup>37</sup>		0/48		0/48		4/48
Godin and colleagues <sup>42</sup>		0/50		0/50		1/50
Harbaugh <sup>47</sup>		2/632		2/632		26/632
Hartsell and colleagues <sup>49</sup>		0/116		10/116		4/116
Love and colleagues <sup>62</sup>		0/200		0/200		23/200
McCleary and colleagues <sup>68</sup>		0/32		0/32		1/32
Muskett and colleagues <sup>75</sup>		1/30		0/30		1/30
Ombrellaro and colleagues <sup>77</sup>		0/140		0/140		28/140
Peitzman and colleagues <sup>83</sup>		1/252		0/252		15/252
Quigley and colleagues <sup>86</sup>		0/114		2/114		5/114
Sbarigia and colleagues <sup>90</sup>		0/37		0/37		1/37
Speziale and colleagues <sup>98</sup>		0/107		2/107		2/107
Stone and colleagues <sup>100</sup>		0/67		4/67		3/67
Takolander and colleagues <sup>107</sup>		0/28		0/28		4/28
Total	0/304	4/3626	9/304	66/3626	22/304	193/3626

**Table 3** Results for case series of superficial (11 studies) and deep block (28 studies). The numerator represents the number of complications in each category; the denominator represents the total number of patients in the study. The last row represents the sum of the rows above

Reference	Serious complications as a result of block		Conversion to general anaesthesia		Total serious complications	
	Superficial	Deep	Superficial	Deep	Superficial	Deep
Burke and colleagues <sup>16</sup>	0/175		0/175		13/75	
Donato and colleagues <sup>29</sup>	0/145		0/145		10/145	
Hafner and Evans <sup>46</sup>	0/1200		0/1200		28/1200	
Harwood and colleagues <sup>50</sup>	0/40		0/40		0/40	
Lee and colleagues <sup>58</sup>	0/305		0/305		12/305	
Levin and Schanno <sup>61</sup>	0/53		0/53		9/53	
Mashiah and colleagues <sup>66</sup>	0/39		0/39		0/39	
Nordstrom and colleagues <sup>76</sup>	0/36		1/36		1/36	
Shifrin and colleagues <sup>95</sup>	0/41		0/41		0/41	
Slutzki and colleagues <sup>97</sup>	0/42		0/42		4/42	
Yared and colleagues <sup>112</sup>	0/100		0/100		6/100	
Agrioglio and colleagues <sup>2</sup>		0/212		0/212		9/212
Benjamin and colleagues <sup>9</sup>		1/81		0/81		5/81
Bergeron and colleagues <sup>10</sup>		1/67		1/67		15/67
Bourke and Crimmins <sup>12</sup>		0/59		0/59		2/59
Breek and colleagues <sup>14</sup>		0/100		0/100		4/100
Castresana and colleagues <sup>20</sup>		1/28		0/28		0/28
Davies and colleagues <sup>25</sup>		0/128		1/128		14/128
Davies and colleagues <sup>24</sup>		0/389		14/389		34/389
Davies and colleagues <sup>26</sup>		8/1000		41/1000		0/1000
Dawson and colleagues <sup>27</sup>		1/26		3/26		0/26
Emery and colleagues <sup>31</sup>		0/40		0/40		0/40
Erwin and colleagues <sup>32</sup>		0/21		1/21		3/21
Faraglia and colleagues <sup>34</sup>		0/35		0/35		0/35
Hobson and colleagues <sup>51</sup>		0/43		0/43		5/43
Junca and colleagues <sup>53</sup>		0/40		0/40		0/40
Lagneau and colleagues <sup>55</sup>		0/137		0/137		2/137
Landesberg and colleagues <sup>56</sup>		0/36		0/36		7/36
Lawrence and colleagues <sup>57</sup>		1/200		17/200		4/200
Leoni and colleagues <sup>59</sup>		0/60		0/60		0/60
Marrocco-Trischitta and colleagues <sup>65</sup>		0/28		0/28		0/28
Merle and colleagues <sup>70</sup>		0/11		0/11		0/11
Molnar and colleagues <sup>73</sup>		1/40		0/40		0/40
Sbarigia and colleagues <sup>89</sup>		0/50		0/50		3/50
Shah and colleagues <sup>94</sup>		0/654		7/654		28/654
Silbert and colleagues <sup>96</sup>		0/70		0/70		4/70
De Sousa and colleagues <sup>28</sup>		0/198		0/198		4/198
Sublett and colleagues <sup>106</sup>		0/18		0/18		2/18
Tissot and colleagues <sup>108</sup>		1/15		3/15		0/15
Total	0/2176	15/3786	1/2176	88/3786	83/2176	145/3786

resulted in more frequent conversions to general anaesthesia and a higher rate of systemic complications.

For non-randomized comparisons of block with general anaesthesia (Table 2), and for case series (Table 3), the incidence of direct complications was higher with deep block. The incidences of conversion to general anaesthesia and systemic complications were similar between the groups for these types of study.

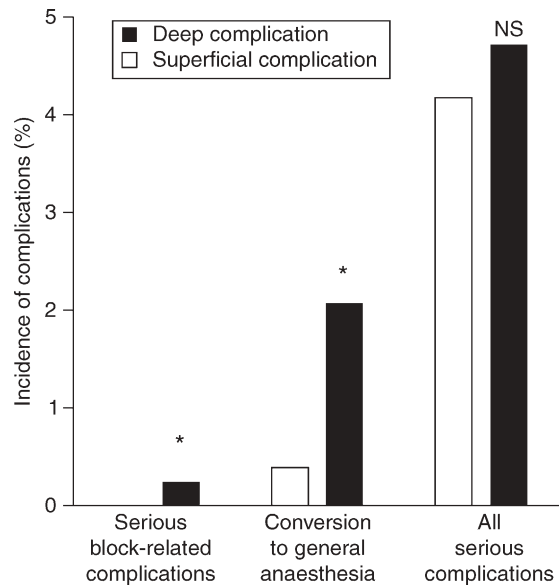
There were a total of 2533 superficial (or intermediate) blocks and 7558 deep (or combined) blocks (Fig. 2). There were no complications arising from block placement in superficial block when compared with 19 (0.25%) in deep ( $P=0.006$ ; odds ratio 2.13; relative risk 2.12). There were 10 (0.39%) conversions to general anaesthesia in superficial when compared with 157 (2.08%) in deep block ( $P<0.0001$ ; odds ratio 5.35; relative risk 5.26). There were a total of 106 (4.18%) serious complications in

superficial when compared with 357 (4.72%) in deep block ( $P=0.273$ ; odds ratio 1.13; relative risk 1.13; NS).

The lower quality evidence in the case reports and letters was not subjected to formal statistical analysis (Table 4). One letter<sup>21</sup> is a brief statement that the authors conducted 28 superficial blocks without complication. Another<sup>19</sup> identifies one seizure in a series of 81 patients which the authors felt was due to local anaesthetic toxicity (due to either the deep block or a top-up by the surgeon). The same authors describe two additional patients who returned to theatre but, because the reasons were not discussed, we did not include these as block complications.

Of the specific complications that occurred with placement of the (deep) block, the most common was intravascular injection, followed by respiratory failure or distress (due to presumed or confirmed diaphragmatic or vocal cord paralysis) (Table 5).





**Fig 2** For each of the three categories of complication, the numerators and denominators in Tables 1–4 are summed, and the ratio expressed as a percentage incidence. \*Indicates that comparisons between deep and superficial block for each category of complication were statistically significant; NS indicates not statistically significant.

The most common reasons to convert to general anaesthesia were block failure, accounting for 40% (all of which occurred with deep block, 69 conversions) and patient anxiety or lack of co-operation, accounting for 45% (66 instances with deep; nine with superficial block). The remaining reasons to convert were insertion of a shunt (11%; 17 patients) and direct complication of block (3%; five patients) with deep block, and shunt insertion (one patient) with superficial block.

The most frequent systemic complications in the perioperative period involved CNS sequelae (e.g. stroke or

TIA) and cardiovascular problems. The former accounted for 56% (70 with superficial block and 191 with deep block). Cardiovascular problems accounted for 23% of the complications: only five in superficial block but 103 in deep block. There were 15 perioperative deaths in the superficial block group and 38 in the deep block group (representing 11% of the complications). The remaining systemic complications were: significant wound haematoma (7%; 13 cases with superficial, 20 cases with deep block) and airway or respiratory complications (three with superficial and five with deep block).

The number of publications has steadily increased over the years (Fig. 3A), with deep block reports consistently more numerous than superficial. Although a single paper using deep block appeared before 1975, papers using superficial block clearly appeared very soon after that, so there is no persuasive evidence that certain epochs exclusively favoured one block type over another. The number of case reports of complications (all of which are for deep block) also increased in line with these trends over the years. The number of patients undergoing blocks in the papers mirrored these trends (Fig. 3B), perhaps with the exception of a single large trial of superficial block in 1988.<sup>46</sup>

## Discussion

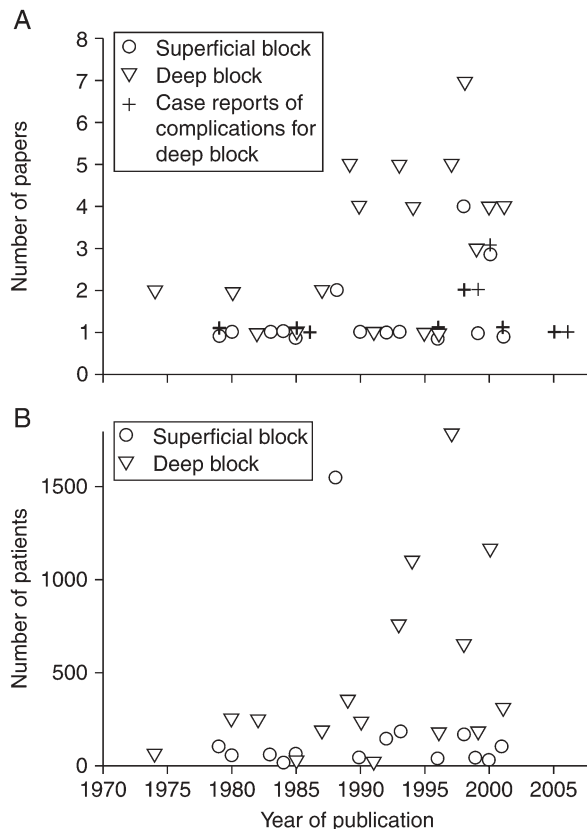
The main conclusion of this review is that the deep block is more than twice as likely to yield a serious life-threatening complication as a result of block placement than is the superficial block. The absolute incidence of block-related complications is, however, low in both groups. Perhaps surprisingly, we also found that the deep block is ~5 times more likely to 'fail' and be converted to general anaesthesia than is the superficial block. As we

**Table 4** Results for case reports concerning complications of deep block (there were no case reports describing complications with superficial block). The numerator represents the number of complications in each category; the denominator represents the total number of patients in the case report. The last row represents the sum of the rows above

Reference	Serious complications as a result of block		Conversion to general anaesthesia		Total serious complications	
	Superficial	Deep	Superficial	Deep	Superficial	Deep
Bourke and Thomas <sup>13</sup>		0/1		0/1		0/1
Carling and Simmonds <sup>18</sup>		2/2		2/2		1/2
Goldberg <sup>43</sup>		1/1		0/1		0/1
Grundy and colleagues <sup>45</sup>		0/1		0/1		1/1
Harris and Benveniste <sup>48</sup>		2/2		0/2		0/2
Cockroft and Brownlow <sup>21</sup>	0/28		0/28		0/28	
Carling and Simmonds <sup>19</sup>		1/81		0/81		0/81
Johnson <sup>52</sup>		1/1		0/1		0/1
Kwok and colleagues <sup>54</sup>		1/1		1/1		0/1
Levelle and Martinez <sup>60</sup>		1/1		1/1		2/2
Madi-Jebara and colleagues <sup>63</sup>		0/2		0/2		0/2
Spiegelberger and colleagues <sup>99</sup>		0/2		0/2		1/2
Stoneham and Wakefield <sup>103</sup>		1/1		0/1		0/1
Stoneham and Bree <sup>101</sup>		0/1		0/1		0/1
Weiss and colleagues <sup>109</sup>		1/1		1/1		0/1
Total	0/28	11/98	0/28	5/98	0/28	5/98

**Table 5** Detailed analysis of specific types of direct complications of placement of cervical plexus block. All studies relate to deep block. In many cases, the specific cause of the direct complication was speculative or probable, rather than proven. The last column indicates the total number of complications in this category for that study (numerator) and the number of patients studied (denominator)

Reference	Intravascular injection	Intrathecal injection	Respiratory failure/distress (e.g. due to diaphragmatic or vocal cord paralysis)	Local anaesthetic toxicity	Total
Harbaugh <sup>47</sup>	2				2/632
Muskett and colleagues <sup>75</sup>	1				1/30
Peitzman and colleagues <sup>83</sup>			1		1/252
Benjamin and colleagues <sup>9</sup>	1				1/81
Bergeron and colleagues <sup>10</sup>	1				1/67
Castresana and colleagues <sup>20</sup>			1		1/28
Davies and colleagues <sup>26</sup>	5		1	2	8/1000
Dawson and colleagues <sup>27</sup>	1				1/26
Lawrence and colleagues <sup>57</sup>				1	1/200
Molnar and colleagues <sup>73</sup>	1				1/40
Tissot and colleagues <sup>108</sup>				1	1/15
Carling and Simmonds <sup>18</sup>		1	1		2/2
Goldberg <sup>43</sup>		1			1/1
Harris and Benveniste <sup>48</sup>			2		2/2
Carling and Simmonds <sup>19</sup>				1	1/81
Johnson <sup>52</sup>	1				1/1
Kwok and colleagues <sup>54</sup>			1		1/1
Levelle and Martinez <sup>60</sup>			1		1/2
Stoneham and Wakefield <sup>103</sup>			1		1/1
Weiss and colleagues <sup>109</sup>			1		1/1
Total	13	2	10	5	—



**Fig 3** (A) Plot of number of papers published for each year, describing the use of: deep block, superficial block, and case reports of complications which are all for deep block. (B) Plot of number of patients undergoing each type of block in the published papers: deep block and superficial block.

expected, there was no difference in the incidence of serious systemic complications between the blocks.

Before we consider the implications of these results for clinical practice, it is important to consider some limitations and strengths of the methods of our review.

Only two of the studies in our analysis were themselves randomized controlled trials (RCTs) which directly addressed the question we posed.<sup>79 102</sup> The Quality of Reporting of Meta-analyses (QUORUM) guidelines emphasize the inclusion of only RCTs<sup>71</sup> and, clearly, our approach was unable to meet these standards due to the paucity of RCTs available. However, the MOOSE guidelines facilitate the inclusion of case series, studies with historical controls, and observational studies, enabling relevant conclusions to be drawn.<sup>105</sup> Nonetheless, the strongest evidence comes from RCTs, and it is important to note that in our analysis, the two RCTs did not differ in their outcomes,<sup>79 102</sup> it was only when data from non-randomized studies are included that differences emerge.

Regardless of adherence to published guidelines, all quantitative systematic reviews or meta-analyses suffer common criticisms, inherent to the technique, which have been discussed elsewhere.<sup>35</sup> There is a concern that it is not valid to combine the results of different studies that were originally designed and conducted at different times, and that had different primary end-points, to answer a 'new' question. Since the primary aim of some of the original studies may not have been to assess complication rate, we cannot be certain that they reported this faithfully. We cannot be certain that we retrieved all published studies, though we are confident that by searching the

main databases it is unlikely that we have missed large or important studies. It is a strength of our systematic approach that we obtained data from non-surgical, non-anaesthetic, and relatively obscure sources.<sup>1 12 14 15 28 66 95</sup> Given these limitations, our conclusions cannot be regarded as definite ‘proof’ of differences between deep and superficial block. Rather, our analysis forms one part of the evidence base.

We included papers from the 1970s.<sup>51 99 106 112</sup> While this added to the completeness of our study, it might be argued that clinical practice has changed since then and it is unjustified to include such work. Furthermore, we did not seek to make direct contact with the authors of all the papers we retrieved. Though desirable, such a venture would have been itself limited by the age of some of the papers and the likely difficulty of making fruitful contact.

We noted that there was no consistency in papers for the definition of ‘perioperative death’ or duration of follow-up to establish such complications. Definitions and follow-up commonly varied from anywhere within the first 24 h after surgery<sup>88</sup> to within 1 month<sup>38</sup> (although one study followed-up patients for 1 yr post-surgery<sup>67</sup>), or it was not defined.<sup>34</sup> We therefore accepted any death classed as ‘perioperative’ by the original authors, so any bias in their classification was not eliminated by our methodology.

We did not search for, or include, unpublished or internal reports, pharmaceutical industry data, or non-peer-reviewed journals. We were careful to exclude case reports from the quantitative analysis. These are published for a variety of reasons and do not necessarily reflect the frequency with which complications arise. Nonetheless, Gillman<sup>41</sup> has recently emphasized the importance of considering evidence from case reports when assessing complications (as opposed to treatment efficacy), and we were impressed with the finding that all adverse events reported concerned the deep block (Table 4).

We restricted our analysis to English language publications. We concede that this may be a possible source of bias: there is evidence that German-based studies with positive results are more likely to be published in English than studies with negative results.<sup>72</sup> However, there is no reason to suppose that such bias would favour one block type over the other.

We are aware that some centres routinely use cervical epidural anaesthesia to facilitate endarterectomy surgery,<sup>11</sup> and we specifically excluded this type of block from our consideration. This was not because we felt cervical epidural to be unimportant, ineffective, or without complications, but that our main consideration was side-effects of superficial and deep cervical plexus injections.

Cervical plexus blocks are also used in thyroid surgery<sup>8</sup> and, by excluding these, we missed some potentially relevant data. However, these blocks are usually bilateral<sup>8</sup> and there are valid statistical reasons to avoid combining data from bilateral with unilateral procedures.<sup>4</sup> Surgical and systemic side-effects differ for thyroid and carotid

artery surgery, so combining these would not be meaningful. A separate systematic review of complication rates for cervical blocks in thyroid surgery may be of use.

In our analysis, we included data from studies that compared one block with general anaesthesia, and we selected data from only the ‘block’ group of patients (Tables 1 and 2). This is an established approach for dealing with data from case series<sup>44 64</sup> and is an appropriate method to assess the rate of complications but is less valid for efficacy of interventions. For this reason, we have been careful to regard the incidence of conversion to general anaesthesia only as a crude measure of efficacy to be interpreted with caution. An important advantage of our systematic approach was that it revealed instances where authors appeared to have used the same data set in more than one publication.<sup>7 47 82 87</sup>

If the conversion rate to general anaesthesia reflects success, then superficial performed better than deep block. Clearly, both techniques are used routinely in major centres without a subjective feeling that one is more effective than the other, and this is borne out by the two randomized studies.<sup>79 102</sup> Nonetheless, there are a number of possible reasons why superficial block might be more effective. First, at least part of the higher incidence of conversion in the deep block group relates to the higher incidence of direct block complications. Secondly, the deep block is more technically challenging and, if undertaken by relatively inexperienced practitioners,<sup>100</sup> might conceivably lead to it performing less well. Indeed, since it is sometimes performed as a three-injection technique, this theoretically increases the risk of direct complication and might plausibly lead to reduced efficacy. However, not all papers specified whether a three-injection or single injection method was used, making it impossible for us to analyse this. Conversion rate to general anaesthesia is certainly a crude measure of block efficacy. It might simply reflect different thresholds in different centres for regarding the block as ‘failed’. A better measure might be the amount of local anaesthetic supplementation by the surgeon, but these data are presented in very few reports, the two RCTs being exceptions.<sup>79 102</sup>

We found the incidence of serious systemic complications to be similar in the two groups. There is no *a priori* reason to suppose that one block has a systemic protective effect over another, and we were reassured that our analysis had not yielded any spurious results in this regard.

In the UK, a trial is underway comparing regional block vs general anaesthesia for carotid endarterectomy ([www.galatrial.com](http://www.galatrial.com)). The trial protocol allows for use of superficial block and deep injection. The results of this trial may therefore enable a subgroup analysis to compare with the complication rates we report here.

In summary, we report the safety of the superficial/intermediate cervical plexus block when used alone when compared with any technique that uses a deep injection.



If the two techniques are equally effective, it would seem appropriate in most cases to employ the technique with the lower incidence of adverse side-effects. From analysis of 2500 cases and 30 yr of publications, it appears that no single instance of a serious complication related to placement of a superficial/intermediate block has ever been formally described.

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