




# Practice advisory on the bleeding risks for peripheral nerve and interfascial plane blockade: evidence review and expert consensus

## Recommandations cliniques sur les risques de saignement lors de la réalisation de blocs des nerfs périphériques et de plan interfascial: compte-rendu des données probantes et consensus d'experts

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**Abstract** *The risk of bleeding complications during regional anesthesia procedures is a significant patient safety consideration. Nevertheless, existing literature provides limited guidance on the stratification of bleeding risk for peripheral nerve and newly described interfascial plane blocks. Our objective was to produce an evidence-based consensus advisory that classifies bleeding risks in*

*patients undergoing regional peripheral nerve and interfascial plane block procedures. This advisory is intended to facilitate clinical decision-making in conjunction with national or local guidelines and to guide consideration for appropriate alterations to anticoagulation regimens before specific regional anesthesia procedures. In pursuit of this goal, the Regional Anesthesia and Acute Pain Section of the Canadian Anesthesiologists Society (CAS) assembled a panel of seven Canadian experts to classify the risk of bleeding complications associated with regional peripheral nerve and interfascial plane blocks. At the 75<sup>th</sup> annual meeting of the CAS in June 2018, the panel's expert opinion was finalized and the published literature was quantified within an organized framework. All common peripheral nerve and interfascial plane blocks were categorized into "low risk", "intermediate risk", and "high risk" based on the literature evidence, bleeding risk scores, and consensus opinion (in that order of priority). Clinical data is often limited, so readers of this consensus report should be reminded that these recommendations are mostly based on expert consensus. Hence, this advisory should not to be defined as a standard of care but rather serve as a resource for clinicians assessing the risk and benefits of regional anesthesia in management of their patients.*

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**Résumé** *Le risque de complications de saignements pendant les interventions sous anesthésie régionale constitue un enjeu important en matière de sécurité des*

*patients. Cependant, la littérature publiée à ce jour ne fournit que peu de recommandations concernant la stratification du risque de saignement en cas de blocs des nerfs périphériques et des blocs du plan interfascial, une technique récemment décrite. Notre objectif était de créer des recommandations consensuelles fondées sur des données probantes qui stratifieraient le risque de saignements chez les patients subissant des interventions de blocs de nerfs périphériques et du plan interfascial. Ces recommandations ont pour but de faciliter la prise de décision clinique en conjonction avec les directives nationales ou locales et d'orienter la réflexion quant à des modifications adaptées à apporter à l'anticoagulation avant certaines interventions d'anesthésie régionale spécifiques. Pour ce faire, la Section d'anesthésie régionale et de douleur aiguë de la Société canadienne des anesthésiologistes (SCA) a rassemblé un panel de sept experts canadiens afin de stratifier le risque de complications de saignement associées aux blocs des nerfs périphériques et du plan interfascial. Lors du 75<sup>e</sup> Congrès annuel de la SCA en juin 2018, l'opinion du panel d'experts a été finalisée et la littérature publiée a été quantifiée dans un cadre structuré. Tous les blocs usuels des nerfs périphériques et du plan interfascial ont été classifiés en « risque faible », « risque intermédiaire » et « risque élevé » selon les données probantes de la littérature, les scores de risque de saignement et l'opinion consensuelle (dans cet ordre de priorité). Les données cliniques sont souvent limitées, c'est pourquoi les lecteurs de ce rapport consensuel doivent garder à l'esprit que ces recommandations sont principalement fondées sur le consensus d'experts. Par conséquent, ces recommandations ne doivent pas servir à définir une norme de soins; plutôt, elles devraient constituer une ressource pour les cliniciens évaluant les risques et bienfaits d'une anesthésie régionale dans la prise en charge de leurs patients.*

Bleeding complications following peripheral regional anesthesia procedures are fortunately quite rare, but when they occur, they can result in significant patient morbidity. The risk of such bleeding complications following regional anesthesia procedures has been the subject of numerous articles and guidelines.<sup>1,2</sup> Recent recommendations classify common regional or pain procedures according to the potential risk of serious bleeding<sup>3</sup> and several excellent reviews<sup>1-3</sup> describe appropriate alterations to anticoagulation regimens based on the risk of the regional anesthesia procedure.

While the most recent American Society of Regional Anesthesia guidelines on regional anesthesia in the setting

of anticoagulation or thrombolytic therapy acknowledge that the clinical consequences of bleeding following a regional anesthesia procedure differ depending on the location, body habitus, site compressibility, associated comorbidities, or anticoagulation status,<sup>1,2</sup> it falls short of risk stratification for individual blocks. Nevertheless, without a clear classification of bleeding risk for specific peripheral nerve or interfascial plane procedures,<sup>1-3</sup> current clinical decisions mostly depend on the individual clinician's *ad hoc* opinion. Understanding the individual procedural bleeding risk may facilitate improved clinical decision-making.

An evidence-based or consensus-based risk assessment of peripheral nerve and interfascial plane blocks is needed. The goal of this advisory is therefore to define the risk of bleeding complications associated with common peripheral regional anesthesia procedures. We present the evidence basis for these recommendations and when insufficient evidence exists, the rationale for stratification based on risk scoring or expert consensus. This advisory is intended to complement existing regional anesthesia guidelines on the management of coagulation. In this way, clinicians can better apply their respective national or local guidelines with appropriate alterations to anticoagulation regimens based on the associated bleeding risk of the specific regional anesthesia procedure.

## Panel creation and consensus process

### Scope

This advisory focuses specifically on the risk of bleeding and its sequelae following peripheral nerve blocks, truncal blocks (such as paravertebral block or intercostal blocks), and interfascial plane blocks. The population considered includes both adult and pediatric patients. The advisory does not address bleeding complications following neuraxial regional anesthesia procedures (such as spinal or epidural anesthesia), facet joint/median branch blocks, or epidural steroid injection. It similarly does not address the risk of non-bleeding complications such as infection or non-bleeding-related neurologic injury related to these procedures. To provide context for the reported bleeding complications, we noted whether or not these occurred in the setting of an altered coagulation status. Nevertheless, the scope of the advisory includes all bleeding complications irrespective of patient's coagulation status.

### Panel composition

In April 2018, the Regional Anesthesia and Acute Pain Section of the Canadian Anesthesiologists' Society (CAS)

convened a panel of seven recognized Canadian experts in regional anesthesia and acute pain medicine to review the evidence and classify the risk of bleeding complications following peripheral regional nerve blocks. The panel was chaired by one of the authors (B.C.H.T.) and the remaining panelists included the chair, vice-chair, two other executive and two general members of the CAS' Regional Anesthesia and Acute Pain Section (2017-2018).

#### Definition of bleeding complications

For the purpose of this advisory, bleeding complications were defined as the occurrence of vascular puncture, active bleeding, or hematoma formation attributable to a peripheral nerve or interfascial plane block. Any such complications that at least necessitated further observation for outcomes such as hemodynamic instability or organ damage, were considered for this report. Reports were also included if trauma subsequent to the block procedure needed additional investigations or interventions to diagnose or treat such complications. Given the rarity of adverse events such as bleeding complications, these may be under-represented in both randomized and non-randomized studies. We therefore considered bleeding complications as attributable to the nerve blocks irrespective of the individual level of supporting evidence.

#### Literature review and consensus methodology

A first meeting of the panelists was convened at the World Congress on Regional Anesthesia and Pain Medicine (New York, April 2018) to discuss the creation of a potential consensus document and to allocate individual panelists to perform the systematic literature reviews for specific anatomic regions including head and neck blocks, upper limb blocks, lower limb blocks, interfascial plane blocks, or paravertebral and intercostal blocks. Each panelist performed the literature search using the MEDLINE and EMBASE databases in May 2018 (see "Literature and search strategy" section).

The panel agreed to the following process for creating the procedure-specific recommendations:

1. Prior to performing the in-depth literature review, each panelist provided their expert opinion of the bleeding risks for each of the common peripheral nerve and interfascial plane blocks.
2. Panelists then participated in a survey assigning a score to each peripheral nerve and interfascial plane block according to a newly proposed bleeding risk Critical, Intervention, and Assessment (CIA) scoring system<sup>4</sup> (Table 1) as a starting point of discussion and consensus formation. This CIA system is organized

around three parameters: 1) whether the block is performed in proximity to a critical structure; 2) whether a bleeding complication would potentially require invasive intervention; and 3) whether it would be difficult to assess the severity of the bleeding complication. A score of 0 or 1 was assigned to each parameter depending on whether it was absent or present, with the total score ranging from 0 to 3. From the total score, the associated risk can be categorized as low risk (CIA = 0), intermediate risk (CIA = 1), or high risk (CIA = 2 or 3). The results of panelist CIA scores are summarized in the Appendix.

3. A level of priority was established to give priority to literature evidence over the CIA score results, which in turn was given priority over consensus-based opinion.
4. When a bleeding complication was attributable to a nerve block, the subsequent sequelae were considered in grading the risk.
5. The consensus opinion and CIA risk scores were used if published evidence for a particular nerve block/interfascial plane block was absent.
6. When a difference occurred between the CIA score and consensus opinion, the final risk assignment was based on overall agreement among all the panelists. In addition, the rationale for the consensus was recorded and described for each block in their corresponding sections.

A second meeting of the panelists was held at the 75<sup>th</sup> Annual Meeting of the Canadian Anesthesiologists' Society in Montreal, Canada (June 2018). The above process was applied at this session resulting in the consensus statement for each peripheral nerve and interfascial plane block.

#### Quality of evidence and grades of recommendation

The quality of evidence obtained from the literature searches was assessed by the panel. The final risk recommendations were subsequently graded using the previously described Statements of Evidence and Grades of Recommendation (Table 2).<sup>5</sup>

#### Literature search strategy

The literature search was conducted in May 2018 using the MEDLINE (January 1966 to April 2018) and EMBASE (January 1980 to April 2018) databases. Search strategies for the respective procedures are summarized as follows:

##### Head and neck blocks

For occipital neck blocks, the terms "occipital nerve block", "occipital nerve blockade", "occipital block",

**Table 1** Bleeding risk score system<sup>4</sup>

Regional anesthesia procedure bleeding risk score		
Parameter (CIA)	Score = 0	Score = 1
Critical	Remote from critical structure	Within or proximal to critical structures (e.g., intracranial, intraspinal, intraocular, retroperitoneal, intrathoracic, or pericardial)
Intervention	Preventable or correctable bleeding or hematoma with non-invasive intervention (e.g., compressible location)	Requires invasive intervention to prevent or correct bleeding or hematoma (e.g., non-compressible location)
Assess	Easy to assess bleeding or hematoma clinically (e.g., superficial site)	Difficult to assess bleeding or hematoma clinically (e.g., deep site)

A score of 0 or 1, was given to each parameter depending on whether it was absent or present. A total score can range from 0 to 3. From this, the risk can be categorized based on the total score as low risk (0), intermediate risk (1), or high risk (2 or 3).

CIA = critical, intervention, and assess

**Table 2** Level of evidence and strength of recommendation<sup>5</sup>

Level of evidence	
Ia	Evidence obtained from meta-analysis of RCTs
Ib	Evidence obtained from at least 1 RCT
IIa	Evidence obtained from at least one well-designed controlled study without randomization
IIb	Evidence obtained from at least one other type of well-designed quasi-experimental study
III	Evidence obtained from well-designed nonexperimental descriptive studies, such as comparative studies, correlation studies, and case reports
IV	Evidence obtained from expert committee reports or opinions and/or clinical experiences of respected authorities
Strength of recommendation	
A	Requires at least one prospective RCT as part of a body of literature of overall good quality and consistency addressing the specific recommendation (evidence levels Ia and Ib)
B	Requires the availability of well-conducted clinical studies, but no prospective RCTs on the topic of recommendation (evidence levels IIa, IIb, III)
C	Requires evidence obtained from expert committee reports or opinions and/or clinical experiences of respected authorities; indicates an absence of directly applicable clinical studies of good quality (evidence level IV)

Source: US Department of Health and Human Services Agency for Health Care Policy and Research (<https://www.ncbi.nlm.nih.gov/books/NBK52152/>).

RCT = randomized-controlled trial.

“occipital blockade” were searched for using the “title/abstract” field. Articles from the initial search results were manually examined for appropriateness in this review. In the case of cervical plexus block, an initial strategy of combining the MeSH terms “cervical plexus” and “nerve block” yielded unsatisfactory results as highly relevant articles<sup>6,7</sup> were not identified. As a result, the strategy was altered to query the “title/abstract” data field instead of MeSH terms. The query string used was “cervical plexus block” OR “cervical plexus nerve block” OR “cervical plexus blockade”. Articles were manually selected from the initial results for appropriateness in this review. After selecting the initial articles, we examined the respective reference lists for additional material.

## Upper limb blocks

MeSH terms “brachial plexus block”, “radial nerve”, “median nerve” and “ulnar nerve” were searched for and combined with the MeSH term “nerve block” using the operator “AND”. Since “interscalene”, “supraclavicular”, “retroclavicular”, “infraclavicular”, “costoclavicular”, “axillary”, “suprascapular”, and “axillary nerve” are not MeSH terms, they were queried as keywords and combined with the MeSH term “nerve block”. From this initial search, only reports of bleeding/aneurysmal complications were retained. We also collected reports from any study or database with > 200 patients that assessed the frequency of vascular puncture with a particular upper extremity

**Table 3** Consensus summary

Body region	Blocks	Consensus	Grades*	Comments
Head and neck	Occipital nerve blocks	Low risk	III-B	No specific studies on bleeding risks; self-limited bleeding reported as secondary outcomes in two RCTs and two case series
	Superficial cervical plexus block (CPB)	Low risk	III-B	No specific studies on bleeding risks; no reports of bleeding from direct needle trauma in numerous studies involving superficial CPB
	Deep cervical plexus	High risk	III-B	No specific studies on bleeding risks; no reports of bleeding from direct needle trauma in numerous studies involving deep CPB
Above clavicle	Interscalene brachial plexus block	Intermediate risk	III-C	Incidental findings in an unrelated RCT or cohort, were considered as a case report
	Supraclavicular brachial plexus block	Intermediate risk	III-C	Incidental findings in an unrelated RCT or cohort, were considered as a case report
Below clavicle	Infraclavicular brachial plexus block	Intermediate risk	III-C	Incidental findings in an unrelated RCT or cohort, were considered as a case report
	Axillary brachial plexus block	Low risk	III-C	Incidental findings in an unrelated RCT or cohort, were considered as a case report
	Median, radial, ulnar nerve block	Low risk	IV-C	No specific data
Lumbar plexus	Lumbar plexus block	High risk	III-B	Multiple reports
	Femoral nerve block	Intermediate risk	III-C	Only one report
	Lateral femoral cutaneous nerve block	Low risk	IV-C	No specific data
	Suprainguinal fascia iliaca block	Intermediate risk	IV-C	No specific data
	Infrainguinal fascia iliaca block	Low risk	IV-C	No specific data
	Obturator nerve block	Intermediate risk	IV-C	No specific data
	Adductor canal nerve block	Intermediate risk	IV-C	No specific data
Sacral plexus	Proximal sciatic nerve block (anterior, transgluteal, subgluteal)	Intermediate risk	IV-C	No specific data
	Popliteal sciatic nerve blocks	Intermediate risk	IV-C	No specific data
Ankle	Ankle block	Low risk	IV-C	No specific data
Interfascial plane	Rectus sheath	Intermediate risk	III-C	The highest evidence is from an RCT but downgraded because of the quality of the study
	Transversus abdominis (TAP) blocks	Intermediate risk	III-C	The highest evidence is from an observational study but downgraded because of the quality of the study
	TAP subcostal	Intermediate risk	IV-C	No specific data
	IIN/IHG	Intermediate risk	III-C	The highest evidence is from case reports
	Quadratus lumborum blocks	High risk	IV-C	No specific data
	Transversalis fascia block	Intermediate risk	IV-C	No specific data
	Erector spinae plane block	Low risk	IV-C	No specific data
	Pectoralis nerve (Pecs) 1	Intermediate risk	III-C	The highest evidence is from an RCT but downgraded because of the quality of the study
	Pectoralis nerve (Pecs) 2	Intermediate risk	IV-C	No specific data
	Serratus anterior plane block	Intermediate risk	IV-C	No specific data
Truncal	Paravertebral block	High risk	III-B	Several large and medium sized case series, case reports and incidental secondary outcome results from unrelated trials
	Intercostal block	Intermediate risk	III-C	No specific studies on bleeding risks; case reports of self-limited but occasionally significant bleeding outcomes

\*See Table 2 for details of the grading system; IIN/IHG = ilioinguinal iliohypogastric nerve; RCT = randomized-controlled trial; TAP = transversus abdominis plane block.

**Table 4** Head and neck (occipital/cervical plexus) reports of vascular and bleeding complications

Author (Ref number)	Adult/pediatric	Study type	Type of block	Needle	Guidance	No. of cases	No. of blocks	No. of adverse events	Type of adverse event	Method of detection	Comments
Harris and Benveniste [17]	Adult	Case report	Superficial + deep cervical plexus block	22G short bevel	Landmark	1	2	1	RLN block	Clinical symptoms	RLN block from cervical plexus block, leading to coughing after carotid endarterectomy, which in turn led to neck hematoma and re-operation
Jurgens <i>et al.</i> [8]	Adult	Case series	Greater occipital nerve block	21G	Landmark	20	38	2	Mild bleeding	Clinical symptoms	No documented further intervention
Na <i>et al.</i> [9]	Adult	RCT	Greater occipital nerve block	27G	Landmark vs doppler	26	26	1	Mild bleeding	Not mentioned	No documented further intervention
Najja <i>et al.</i> [10]	Adult	RCT	Greater + lesser occipital nerve block	24G	Nerve stimulation	50	50	1	Minor subcutaneous hematoma	Not mentioned	No documented further intervention
Sahin <i>et al.</i> [11]	Adult	Retrospective case series	Greater occipital nerve block	Undefined	Landmark	69	212	1	Local hematoma	Not mentioned	No documented further intervention

RCT = randomized-controlled trial; RLN = recurrent laryngeal nerve.

regional anesthesia technique. After selecting the initial articles, we examined the respective reference lists for additional material.

#### Lower limb blocks

MeSH terms “lumbosacral plexus”, “femoral nerve”, “obturator nerve”, “saphenous nerve”, “sciatic nerve”, “peroneal nerve”, and “tibial nerve” were searched for and combined with the MeSH term “nerve block” using the operator “AND”. Since “lumbar plexus”, “psoas compartment”, “psoas sheath”, “sacral plexus”, “fascia iliaca”, “three-in-one”, “3-in-1”, “femoral triangle”, “adductor canal”, “lateral femoral cutaneous”, “posterior femoral cutaneous”, “ankle”, and “ankle block” are not MeSH terms, they were queried as keywords and combined with the MeSH term “nerve block”. From this initial search, only reports of bleeding/aneurysmal complications were retained. After selecting the initial articles, we examined the respective reference lists for additional material.

#### Interfascial plane blocks

The terms “interfascial plane block”, “transversus abdominis plane block”, “serratus plane block”, “subcostal TAP block”, “posterior TAP block”, “four quadrant TAP block”, “dual TAP block”, “LM-TAP”, “lateral TAP block”, “rectus sheath block”, “quadratus lumborum block”, “QLB”, “PECS 1 block”, “PECS 2 block”, “PECS block”, “pectoral nerve block”, “serratus plane block”, “ilioinguinal nerve”, “iliohypogastric nerve”, “ilioinguinal nerve block”, “iliohypogastric nerve block”, “erector spinae plane block”, and “thoraco-lumbar interfascial plane block” were searched for and combined with the keywords “hemorrhage” or “hematoma” or “vascular system injuries” using the operator “AND”. The strategy to combine bleeding and nerve block-related search terms returned few results. Accordingly, all abstracts from the reports of interfascial blocks were manually reviewed to seek reports of procedural complications such as hematoma, bleeding, or visceral injury. The full text of studies reporting block-related complications were retrieved for data extraction with selected articles then categorized into prospective studies or case reports/case series. After selecting the initial articles, we examined the respective reference lists for additional relevant material.

#### Truncal blocks

For paravertebral block, the MeSH terms “nerve block” OR “conduction anesthesia” were searched for and



**Table 5** Upper extremity peripheral nerve/plexus block reports of vascular and bleeding complications

Author (Ref number)	Adult/pediatric type	Study type	Type of block	Needle	Guidance	No. of cases	No. of blocks	No. of adverse events	Type of adverse event	Method of detection	Comments
Ekatodramis <i>et al.</i> [26]	Adult	Case report	Interscalene	21G, short bevel stimulating needle	Nerve Stimulation	2	2	2	Hematoma (4x5 cm & 3x4 cm) both with prolonged Horner Syndrome which resolved after one year	Ultrasound	
Clendenen <i>et al.</i> [31]	Adult	Case report	Interscalene	Insulated 5-cm, 17G Tuohy needle	Nerve Stimulation	1	1	1	Hematoma	Palpation and biopsy	Right external jugular vein was accidentally punctured during nerve localization with first catheter, which became dislodged and was replaced on POD2. Catheter removed at home POD5. POD8 patient presented to surgeon with sepsis
Howell <i>et al.</i> [32]	Adult	Case report	Interscalene	18G Tuohy needle	Nerve Stimulation (initially) and Nerve Stimulation + Ultrasound (subsequently)	1	1	1	Hematoma	Ultrasound	Hematoma was immediately apparent and obstructed superficial landmarks. Subsequently, an evaluation of hematoma and placement of a peripheral nerve catheter were completed with ultrasound guidance
Gleaton <i>et al.</i> [44]	Adult	Case report	Infraclavicular	8.89-cm 20G Tuohy	Ultrasound	1	1	1	Mycotic aneurysms	Ultrasound, CT angiography	Patient history of IVDU, endocarditis, and mitral valve replacement Patient presented two weeks postop with two mycotic aneurysms fed by the right lateral branch of the dorsoscapular artery and the right thoracoacromial artery, respectively
Frederiksen <i>et al.</i> [53]	Adult	RCT	Axillary	22G, 80-mm stimulating needle	Ultrasound	40	40	1	Minor hematoma	Not stated	
Zipkin <i>et al.</i> [59]	Adult	Case report	Axillary	22G needle	Transarterial	1	1	1	Large hematoma and pseudoaneurysm requiring surgical exploration and ligation		The patient had an associated ulnar paresthesia that resolved after resection of the pseudoaneurysm
Torres Moreta <i>et al.</i> [60]	Adult	Case report	Axillary	24G 55-mm insulated needle	Nerve stimulation	1	1	1	Hematoma of the arm treated with surgical exploration and evacuation	Clinical examination	Inadvertent vascular puncture was noted during the procedure. Not stated if direct pressure was placed after the block

Table 5 continued

Author (Ref number)	Adult/pediatric type	Study type	Type of block	Needle	Guidance	No. of cases	No. of blocks	No. of adverse events	Type of adverse event	Method of detection	Comments
Ben-David <i>et al.</i> [57]	Adult	Case report	Axillary	22G short bevel needle	Transarterial	1	1	1	Large axillary hematoma		The axillary hematoma (treated conservatively) was associated with radial neuropraxia, which resolved within six months
Groh <i>et al.</i> [58]	Adult	Case report	Axillary	25G 1.9-cm needle	Transarterial	1	1	1	Right axillary artery pseudoaneurysm requiring surgical ligation		Pseudoaneurysm was associated with a median nerve deficit, which did not recover

CT = computed tomography; IVDU = intravenous drug use; POD = postoperative day; RCT = randomized-controlled trial.

combined with the keywords “regional anesthesia”, “regional anaesthesia”, “conduction block” OR “conduction anaesthesia” using the operator “OR”. The results of this search were combined with the keywords “paravertebral” OR “paravertebral block” using the operator “AND”. Articles from the initial search were manually examined for appropriateness in this review. In the case of intercostal block, the MeSH terms “nerve block” OR “conduction anesthesia” were searched for and combined with the keywords “regional anesthesia”, “regional anaesthesia”, “conduction block” OR “conduction anaesthesia” using the operator “OR”. The results of this search were combined with the keywords “intercostal” OR “intercostal block” using the operator “AND”. Similarly, all results from this initial search were manually reviewed for appropriateness in this review. After selecting the relevant articles from each search, we examined the respective reference lists for additional relevant material.

## Evidence review and risk classification consensus

### Head and neck blocks

#### *Evidence review*

*Occipital nerve block* Both the greater and lesser occipital nerves can be blocked by superficial injections in the posterior neck along the inferior nuchal line.<sup>8</sup> While the occipital artery is adjacent to the greater occipital nerve, it is commonly assumed that significant bleeding complications are rare because of the superficial nature of this block.

Eighty-one original articles involving occipital nerve blocks were identified. The majority involved isolated greater occipital nerve block (73 articles) or combined greater and lesser occipital nerve blocks (six articles). Jurgens *et al.* reported that two out of 20 study patients developed mild localized bleeding after greater occipital nerve blocks for craniofacial neuralgias.<sup>8</sup> Similar mild bleeding occurred in two studies where patients received greater occipital nerve blocks for headaches.<sup>9-11</sup> None of these bleeding complications resulted in invasive intervention or prolonged adverse effects.

*Cervical plexus block (superficial/intermediate/deep)* Traditionally, cervical plexus blocks are classified as superficial (subcutaneous injection at the midpoint of the posterior border of the sternocleidomastoid muscle) or deep (injections next to C2–C4 transverse processes deep to the prevertebral fascia).<sup>12</sup> More recently an “intermediate” approach has been proposed,<sup>12,13</sup> where



**Table 6** Upper extremity peripheral nerve/plexus block databases or studies (> 200 patients) that report bleeding complications or vascular puncture

Author (reference number)	Adult/ pediatric	Study type	Type of block	Needle	Guidance	No. of cases	No. of blocks	No. of adverse events	Type of adverse event	Method of detection	Comments
Liu <i>et al.</i> [23]	Adult	Prospective database	Interscalene	22G	Ultrasound	515	515	0	Inadvertent vascular puncture	Aspiration	
Liu <i>et al.</i> [23]	Adult	Prospective database	Supraclavicular	22G	Ultrasound	654	654	0	Inadvertent vascular puncture	Aspiration	
Taenzer <i>et al.</i> [24]	Pediatric	Prospective database	Interscalene	Not reported	Ultrasound (88%), nerve stimulation (2.5%), no location (7.7%), with no location device, and 2.5% with a nerve stimulator	518	518	1	Inadvertent vascular puncture		
Orebaugh <i>et al.</i> [25]	Adult	Retrospective database	Interscalene	Not reported	Ultrasound (55%), nerve stimulation (45%)	1,985	1,985	0	Hematoma		
Orebaugh <i>et al.</i> [25]	Adult	Retrospective database	Axillary block	Not reported	Ultrasound (70%), nerve stimulation (30%)	316	316	0	Hematoma		
Borgeat <i>et al.</i> [30]	Adult	Prospective database	Interscalene	21 or 22G insulated needle, OR 20G cannula-over-needle	Nerve stimulation	520	520	3	Inadvertent vascular puncture		No hematomas
Wiegel <i>et al.</i> [27]	Not stated	Prospective database	Interscalene	Not defined	Nerve stimulation	221	221	0	Inadvertent vascular puncture		
Pöpping <i>et al.</i> [28]	Adult	Prospective database	Interscalene & axillary	Not defined	Not defined	1,737	1,737	16	Inadvertent vascular puncture		No hematomas
Bert <i>et al.</i> [29]	Adult	Retrospective database	Interscalene	22G 2-inch insulated needle	Nerve stimulation	1,914	1,914	0	Hematoma		
Perlas <i>et al.</i> [37]	Adult	Prospective database	Supraclavicular	2-in, 22G insulated needle	Ultrasound	510	510	2	Inadvertent vascular puncture		No hematomas
Hanouz <i>et al.</i> [46]	Adult	Prospective database	Axillary	22G, 50-mm short-beveled insulated needle	Nerve stimulation	605	605	51	Inadvertent vascular puncture		No hematomas reported
Stan <i>et al.</i> [48]	Adult	Prospective database	Axillary	24G 1.5-in medium bevel needle	Transarterial	996	996	2	Inadvertent vascular puncture		Two hematomas
Pearce <i>et al.</i> [49]	Adult	Prospective database	Axillary	22G short-beveled needle	Paresthesia and transarterial	200	200	26	Axillary tenderness and bruising		

Table 7 Lower extremity reports of vascular and bleeding complications

Author (reference number)	Adult/pediatric	Study type	Type of block	Needle	Guidance	No. of cases	No. of blocks	No. of adverse events	Type of adverse event	Method of detection	Comments
Aida <i>et al.</i> [62]	Adult	Case report	Lumbar plexus block	20G	Loss of resistance	2	1	N/A	Renal subcapsular hematoma	Case 1: CT Case 2: CT and US	
Klein <i>et al.</i> [63]	Adult	Case report	Lumbar plexus block	21G	Nerve stimulation	1	1	N/A	Psoas hematoma (and lumbar plexopathy)	CT	19.5 hr after enoxaparin (30 mg BID)
Dauri <i>et al.</i> [66]	Adult	Letter to the editor	Lumbar plexus block	?	Nerve stimulation	1	1	N/A	Retroperitoneal hematoma (without plexopathy)	CT	Catheter removal 12 hr after last dose of enoxaparin (4000 UI BID)
Aveline and Bonnet [65]	Adult	Case report	Lumbar plexus block	21G	Nerve stimulation	1	1	N/A	Delayed retroperitoneal hematoma	CT	Factor V Leyden on enoxaparin 60 mg BID Enoxaparin held 24 hr before block
Weller <i>et al.</i> [64]	Adult	Case report	Lumbar plexus block	21G	Nerve stimulation	2	1	N/A	Extensive retroperitoneal hematoma (without neurologic deficit)	Both cases: CT	Case 1: catheter removal 100 min after last dose of enoxaparin (30 mg)
Warner, <i>et al.</i> [67]	Adult	Retrospective case report	Lumbar plexus block	18G	Nerve stimulation	1	1	N/A	Retroperitoneal hematoma	CT	Myelodysplastic syndrome on high dose aspirin (325 mg BID) for DVT prophylaxis.
Wiegel <i>et al.</i> [27]	Adult	Observational	Femoral	?	Nerve stimulation	1	1	N/A	Retroperitoneal hematoma (leading to compression injury of the femoral nerve).	CT	
Rodriguez <i>et al.</i> [68]	Adult	Case report	Femoral	?	Nerve stimulation	1	1	N/A	Intraneural hematoma	CT	Undiagnosed factor XI deficiency

CT = computed tomography scan; DVT = deep vein thrombosis; N/A = not available; US = ultrasound.

**Table 8** Interafascial block reports of complications

Author (reference number)	Adult/pediatric	Study type	Type of block	Needle	Guidance	No. of cases	No. of blocks	No. of adverse events	Type of adverse event	Method of detection	Comments
Cros <i>et al.</i> [73]	Adult	RCT	PECS-1	50- or 80-mm, 22G needle under	Ultrasound	127	127	3	Pectoral hematoma and bleeding	Detected by the study as a secondary outcome	
Dolan <i>et al.</i> [86]	Adult	RCT	RS	22G, 3.81-cm block needle	Loss of resistance	42	168	35	Intraperitoneal injection	Ultrasound	34.5% superficial to RS and 20.9% intraperitoneal
Farooq and Carey [87]	Adult	Case report	TAP	Blunt regional anesthesia needle (22G, Plexufix®, B.Braun)	Loss of resistance	1	2	1	Liver injury	Laparotomy	TAP block using LOSS OF RESISTANCE technique via triangle of petit. 50 ml fresh blood detected at laparotomy. Liver enlarged up to iliac crest
Hotujec <i>et al.</i> [75]	Adult	RCT	TAP	Not mentioned	Ultrasound	64	64	1	Not mentioned	Not mentioned	TAP blocks are safe in patients with high BMI
Jankovic <i>et al.</i> [76]	Adult	Case report	TAP	Not mentioned	Not mentioned	1	1	1	Peritoneal puncture and intraperitoneal catheter	Laparotomy	The tip of the TAP catheter was found to be in the abdomen, (without any visceral organ damage) and 20 mL 0.375% levobupivacaine (3.75 mg/mL) had been injected intraperitoneally
Lancaster and Chadwick [78]	Adult	Case report	TAP	50-mm 22G regional block needle	Ultrasound	1	2	1	Peritonitis and liver injury	CT scan showed perihaptic blood. Patient had signs of peritonitis and drop in Hb	Injury here was likely due to a failure to accurately image the entire needle during the right-sided needle placement, resulting in excessive depth of penetration
Long <i>et al.</i> [79]	Pediatric	Observational	TAP	N/A	Ultrasound: 1,994; no ultrasound: 49; unknown: 58	1,994	2	2	Vascular puncture: 1; peritoneal puncture: 1	Recognized by the anesthesia provider	0.2% complication rate

Table 8 continued

Author (reference number)	Adult/pediatric	Study type	Type of block	Needle	Guidance	No. of cases	No. of blocks	No. of adverse events	Type of adverse event	Method of detection	Comments
Shirozu <i>et al.</i> [81]	Adult	Case report	TAP	20G 80.0 × 1.0-mm epidural needle	Ultrasound	1	2	1	Intramuscular hematoma	One day after surgery, the patient complained of abdominal pain, and a left lateral abdominal skin induration was seen around the needle insertion point. Abdominal ultrasound showed left abdominal wall hyperplasia, and an intramuscular hematoma was suspected. Intramuscular and subcutaneous hematomas were detected by enhanced CT	Managed conservatively. PTT and platelets were deranged after the performance of the block
Ueshima and Otake [83]	Adult	Observational	PECS	20G Tuohy needle	Ultrasound	498	498	8	Hematoma	Not mentioned	Five of these patients had taken oral anticoagulants and antiplatelet drugs
Yuen and Ng [85]	Adult	Case report	RS	21G hypodermic needle	Four-point injection technique	1	2	1	Retropertitoneal hematoma	Blood was aspirated, and the injection was abandoned + CT scan	Postoperative computed tomography of the abdomen revealed a retroperitoneal density 2-cm thick in the periaortic region and anterior to the inferior vena cava in the infrarenal portion down to the bifurcation, compatible with the retroperitoneal hematoma. The patient recovered fully, and the hematoma resolved spontaneously
Ueshima [82]	Adult	Case report	ESP	Not mentioned	Ultrasound	1	1	1	Pneumothorax	Ultrasound	Pneumothorax detected with ultrasound, needed chest tube drainage
Amory <i>et al.</i> [72]	Pediatric	Case report	IIN/IHG	24G short bevel needle	Loss of resistance	1	1	1	Small bowel hematoma	Patient was readmitted five days later with signs of intestinal obstruction. Diagnostic laparoscopy showed subserosal hematoma causing intestinal obstruction	Patient required small bowel resection

Table 8 continued

Author (reference number)	Adult/ pediatric	Study type	Type of block	Needle	Guidance	No. of cases	No. of blocks	No. of adverse events	Type of adverse event	Method of detection	Comments
Frigon <i>et al.</i> [74]	Pediatric	Case report	IIN/ IHG	Short bevel needle (Plexufix 24G, 2.5 cm; B-Braun Medical)	Loss of resistance	1	1	1	Small bowel hematoma	After opening the peritoneum, a subserosal small bowel hematoma was noted in the wall of the terminal ileum	No technical complications noted with the two-pop technique. Surgical team opted for conservative management. Discharged on POD 2
Johr and Sossai [77]	Pediatric	Case report	IIN/ IHG	1 1/4-in. 22G long bevel needle	Loss of resistance	1	1	1	Colonic injury	Small laceration and subserosal hematoma formation in the colon diagnosed following exposure of the spermatic vein for ligation as a dark blue structure underneath the peritoneum	Puncture was secured with a seromuscular suture and the peritoneum was closed. Patient's course was uneventful postoperatively
Parvaiz <i>et al.</i> [80]	Adult	Case report	IIN/ IHG	21G hypodermic needle (1.5 inch)	Loss of resistance	1	1	1	Retropertitoneal hematoma	Patient was readmitted nine days later for right flank pain and anemia. CT scan revealed a large right retroperitoneal hematoma (22×10×7 cm).	Patient had a h/o aspirin and dipyridamole intake for CRVO but only aspirin was stopped before the surgery. Angiogram revealed active bleeding through right deep circumflex iliac artery which was embolized. Patient was discharged two days after embolization
Visoiu and Pan [93]	Pediatric	Case report	QLB	22G Sono TAP needle	Ultrasound	2	2	2	Quadratus lumborum hematomas	Delayed presentation of hematomas as skin bruising on postoperative days 5 and 8.	Both patients had pain out of proportion to that of surgical site. One patient had heparin 3.5 hr after QLB. The delay in presentation as skin bruising could have been due to the time taken for the blood to track through the interfascial planes to skin.

CRVO = central retinal vein occlusion; ESP = erector spinae plane block; IIN/IHG = ilioinguinal iliohypogastric nerve block; PECS = pectoral nerve blocks; RCT = randomized-controlled trial; RS = rectus sheath block; TAP = transversus abdominis plane block; QLB = quadratus lumborum block.

**Table 9** Truncal (paravertebral/intercostal) reports of vascular and bleeding complications

Author (reference number)	Adult/ pediatric	Study type	Type of block	Needle	Guidance	No. of cases
Naja and Lonnqvist [97]	Adult and pediatric	Prospective observational case series	Single shot paravertebral	22G insulated block needle	Anatomic	620 adults 42 children
Visoiu and Cassara [98]	Pediatric	Randomized-controlled trial	Single shot paravertebral	22G Tuohy	Anatomic loss of resistance	41
Lonnqvist <i>et al.</i> [99]	Adult and pediatric	Prospective observational case series	105 continuous paravertebral 262 single shot paravertebral	Tuohy or 18G Venflon	Anatomic	319 adults 48 children
Berta <i>et al.</i> [100]	Pediatric	Prospective observational case series	Single shot paravertebral	20G Tuohy	Anatomic loss of resistance	24
Canto <i>et al.</i> [101]	Adult	Prospective observational case series	Bilateral continuous paravertebral	16G Tuohy	Anatomic loss of resistance	111
Gieri <i>et al.</i> [102]	Adult	Retrospective observational case series	Continuous paravertebral	18G Tuohy	Anatomic	342
Sopena-Zubiria <i>et al.</i> [103]	Adult	Prospective observational case series	Single shot paravertebral	Not reported	Anatomic	100
Borle <i>et al.</i> [104]	Adult	Randomized-controlled trial	Unilateral continuous paravertebral	16G Tuohy	Anatomic	25
Berta <i>et al.</i> [105]	Pediatric	Prospective observational case series	Single shot paravertebral	Not reported	Anatomic loss of resistance	8
Pamaik <i>et al.</i> [106]	Adult	Randomized-controlled trial	Multilevel single shot and continuous paravertebral	18G Tuohy	Anatomic compared with ultrasound	36 anatomic 36
ultrasound						
Fallatah and Mousa [107]	Adult	Randomized-controlled trial	Single shot paravertebral	20G Tuohy	Anatomic	20
Chalam <i>et al.</i> [108]	Pediatric	Randomized-controlled trial	Single shot paravertebral	21G hypo-dermic needle	Ultrasound	100
Moawad <i>et al.</i> [109]	Adult	Randomized-controlled trial	Single shot paravertebral	Tuohy	Anatomic	40
Sanchez <i>et al.</i> [110]	Adult	Prospective observational case series	Continuous paravertebral	Not reported	Ultrasound	105
Adriani and Evangelou [111]	Not reported	Retrospective case series of all regional anesthesia	Single shot paravertebral	Not reported	Not reported	
Okitsu <i>et al.</i> [112]	Adult and pediatric	Retrospective observational case series	Continuous paravertebral	18G Tuohy	Ultrasound	141
Vecchione <i>et al.</i> [113]	Pediatric	Retrospective observational case series	Single shot and continuous paravertebral	Not reported	Anatomic and ultrasound	871
Weismueller <i>et al.</i> [114]	Pediatric	Retrospective case series	Continuous paravertebral	Not reported	Ultrasound	21
Matthes <i>et al.</i> [115]	Pediatric	Retrospective case series	Continuous paravertebral	Not reported	Ultrasound	214
Kadomatsu <i>et al.</i> [116]	Adult	Randomized-controlled trial	Continuous paravertebral	18G Tuohy	Anatomic	26



Table 9 (continued)

Author (reference number)	Adult/pediatric	Study type	Type of block	Needle	Guidance	No. of cases
Thomas <i>et al.</i> [117]	Adult	Case report	Paravertebral	16G Tuohy	Anatomic loss of resistance	1
Dangoisse <i>et al.</i> [131]	Adult	Case report	Percutaneous continuous intercostal and single shot intercostal	Not reported	Anatomic	1
Baxter <i>et al.</i> [132]	Adult	Case report	Percutaneous continuous intercostal	17G Tuohy	Anatomic	1
Nielsen [133]	Adult	Case report	Repeated (four times) bilateral single shot intercostal blocks at five levels	22G block needle	Anatomic	1
Shankar and Eastwood [134]	Adult	Case series	Percutaneous intercostal steroid injection	25G	Fluoroscopy	26
Kadomatsu <i>et al.</i> [116]	Adult	Randomized-controlled trial	Percutaneous intercostal catheter	18G Tuohy	Anatomic	24
Author (reference number)	No. of blocks	No. of adverse events	Type of adverse event	Method of detection	Comments	
Naja and Lonnqvist [97]	858	15	Local superficial hematoma	Direct visualization	No intervention beyond superficial compression was required in any case	
Visoiu and Cassara [98]	123	42	Inadvertent vascular puncture	Aspiration of blood		
Lonnqvist <i>et al.</i> [99]	367	1	Inadvertent vascular puncture	Not reported	PVB vs local anesthesia. No bleeding complications	
Berta <i>et al.</i> [100]	24	14	Inadvertent vascular puncture	Aspiration of blood	Repeat vascular puncture in one case led to abandoning the procedure	
Canto <i>et al.</i> [101]	222	2	Inadvertent vascular puncture	Aspiration of blood	No intervention required, procedures completed	
Gieri <i>et al.</i> [102]	527	9	Inadvertent vascular puncture	Aspiration of blood	All patients heparinized after block placement for cardiopulmonary bypass, no block-related serious bleeding complications	
Sopena-Zubiria <i>et al.</i> [103]	300	2	One case of inadvertent vascular puncture, one case of superficial serosanguinous oozing	Aspiration of blood and direct observation	All patients on enoxaparin 30 mg subcutaneous twice a day	
Borte <i>et al.</i> [104]	25	3	Inadvertent vascular puncture	Not reported	No serious bleeding outcomes reported	
Berta <i>et al.</i> [105]	8	3	Inadvertent vascular puncture	Aspiration of blood	PVB vs GA alone	
Pamaik <i>et al.</i> [106]	432	1	Incidental vascular puncture	Not reported	Slight catheter withdrawal in two patients and re-siting in one. No serious bleeding complications	
Fallatah and Mousa [107]	100	2	Inadvertent vascular puncture	Aspiration of blood	No serious bleeding outcomes reported	
Chalam <i>et al.</i> [108]	100	2	Inadvertent vascular puncture	Aspiration of blood	Anatomic vs ultrasound localization	
		3	Inadvertent vascular puncture	Not described	Both events occurred in the anatomic group. No events were noted in the ultrasound-guided group	
					PVB vs IV PCA	
					Bupivacaine vs ropivacaine	
					No serious bleeding complications described	

Table 9 (continued)

Author (reference number)	No. of blocks	No. of adverse events	Type of adverse event	Method of detection	Comments
Moawad <i>et al.</i> [109]	40	1	Inadvertent vascular puncture	Positive aspiration of blood	PVB vs epidural
Sanchez <i>et al.</i> [110]	105	1	Inadvertent vascular puncture	Aspiration of blood	
Adriani and Evangelou [111]		1	Needle puncture of thoracic aneurysm	Not described	One reported case in a descriptive review of 1,400 regional nerve blocks
Okitsu <i>et al.</i> [112]	135	1	Mild superficial bleeding	Direct observation	All patients had either coagulation abnormality or were on anticoagulant/antiplatelet therapy
Vecchione <i>et al.</i> [113]	625 catheters 1765 single injections	2	Minor local bleeding at insertion site	Not reported	Both events in continuous block patients.
Weismueller <i>et al.</i> [114]	42	1	Minor bleeding	Not reported	
Matthes <i>et al.</i> [115]	237	2	Minor bleeding	Not reported	
Kadomatsu <i>et al.</i> [116]	26	5	Hematoma under parietal pleura	Direct visualization by surgeon during VATS	PVB vs intercostal. No intervention required. Pain scores higher postoperatively in patients experiencing hematoma
Thomas <i>et al.</i> [117]	1	1	Aspiration of blood and subsequent pulmonary hemorrhage with intrathoracic hematoma	Aspiration of blood, blood from endotracheal tube and visualization during thoracotomy	Rigid bronchoscopy performed but no intervention required
Dangoisse <i>et al.</i> [131]	2	2	1) Superficial hematoma after catheter insertion 2) Later, large hemothorax after single shot block	1) Superficial visualization 2) Chest x-ray and then chest tube following symptoms of blood loss 5 days after block procedure	Blocks were separated in time by 14 days. Patient had congenital syndrome affecting urologic anatomy but no coagulopathy
Baxter <i>et al.</i> [132]	1	1	Flank hematoma	Superficial visualization	Post cardiac surgery with transient elevated PT and PTT after block placement
Nielsen [133]	40	1	Chest wall and flank hematoma	Superficial visualization and drop in hematocrit	Blocks repeated four times over two days. Concurrent initiation of 5,000 U SC heparin TID followed by continuous IV infusion for mechanical heart valve
Shankar and Eastwood [134]	26	2	Intravascular injection	Dye spread on fluoroscopy	No hematoma or bleeding complication noted from vascular puncture
Kadomatsu <i>et al.</i> [116]	24	2	Local hematoma	Visualization of internal thoracic wall during VATS	PVB vs intercostal Catheters placed percutaneously by surgeon intraoperatively

GA = general anesthesia; IV = intravenous; PCA = patient-controlled analgesia; PT = prothrombin time; PTT = partial thromboplastin time; PVB = paravertebral block; SC = subcutaneously; VATS = video-assisted thoracoscopic surgery.

local anesthetic is injected deep to the investing fascia of the neck rather than the subcutaneous injection employed in the superficial approach.

In total, 209 articles were identified relating to the various depths of cervical plexus block. There were no reported cases of bleeding complications arising from cervical plexus blocks in the literature, regardless of approach. Several articles reported neck hematoma formation postoperatively after carotid endarterectomy, thyroidectomy, or maxillofacial surgery.<sup>7,14-16</sup> Nevertheless, all of these hematomas were attributed to surgical complications rather than the block itself. The only block-related bleeding complication reported was not due to direct needle trauma.<sup>17</sup> Instead, a combined superficial plus deep cervical plexus block for carotid endarterectomy inadvertently caused a recurrent laryngeal nerve block. Subsequent aspiration and coughing led to surgical site bleeding and hematoma formation.

### Risk classification consensus

#### Occipital nerve block

The occipital nerves are located in an area that is easily compressible should bleeding occur. Even were significant bleeding to occur, the posterior scalp is devoid of any major structure that would be at risk from the mass effect of a hematoma. The evidence confirms that the occipital nerve block is a safe procedure with a low risk of bleeding complications as all bleeding/hematoma cases in the literature were self-limiting and required no interventions. The panel therefore recommends that the occipital nerve block be classified as low risk for bleeding complications.

#### Cervical plexus block

There is minimal evidence in the literature to guide risk stratification for the different approaches to the superficial cervical plexus block. In all approaches, the needle should only traverse the superficial tissue layers and its tip should remain superficial to the prevertebral fascia. As such, any bleeding will be easily assessable and compressible, and the mass effect of a hematoma in this location will be insignificant. The panel therefore recommends that the superficial cervical plexus block be classified as low risk for bleeding complications.

The bleeding risk for deep cervical plexus block is less clear. While there are no reports of significant bleeding directly resulting from deep cervical plexus blocks, various critical anatomical structures are at potential risk of injury when the needle penetrates the prevertebral fascia. These include blood vessels such as the vertebral artery, dorsal

scapular artery, and suprascapular artery. There are reports of direct injection of local anesthetic into the vertebral artery<sup>18-20</sup> and subarachnoid space<sup>20,21</sup> during deep cervical plexus blocks. Bleeding from these deeper vessels may be occult, difficult to tamponade non-invasively, and the mass effect from an expanding hematoma in the neck could have significant consequences. The panel therefore recommends that the deep cervical plexus block be classified as high risk for bleeding complications.

One of the most common indications for cervical plexus block is anesthesia or analgesia for carotid endarterectomy. This population warrants special consideration as the pathology often dictates that the patients remain on antiplatelet or anticoagulation therapies up to the time of surgery. A prospective case series reported no bleeding complications with patients taking antiplatelet/anticoagulation medications at the time of the superficial plus deep cervical plexus blocks.<sup>22</sup> The panel recommends that the decision to perform cervical plexus blocks in this population should rest on a careful assessment of specific risks and benefits applicable to the individual patient and practitioner.

### Upper limb blocks

#### Evidence review

##### *Interscalene block*

Despite the superficial location, there are many arterial structures in the interscalene region of the neck, including the dorsal scapular, transverse cervical, and vertebral arteries, any of which may be punctured during needle advancement.

In large (> 200 patients) prospective and retrospective databases, there is a low incidence of vascular puncture during interscalene block, with reported rates between 0 and 0.63%.<sup>23-29</sup> These databases together captured more than 5,700 interscalene blocks and reported no cases of hematoma. Nevertheless, it is possible that the incidence of both vascular puncture and hematoma are under-reported. There are three case reports of hematoma<sup>30-32</sup> after interscalene block, though none of these occurred using an ultrasound-guided technique. There have been six spinal cord injuries<sup>33-36</sup> reported after interscalene block, representing severe injury to a critical structure in close proximity to the needle position. Again, none of the reported spinal cord injuries occurred in the context of an ultrasound-guided technique.

### *Supraclavicular block*

There are many arterial structures in the supraclavicular region, including the subclavian, dorsal scapular, and transverse cervical, which may be at risk during needle advancement.

In large (> 200 patients) prospective and retrospective databases, the incidence of vascular puncture during supraclavicular block was noted to be between 0 and 0.4% with no reported hematomas.<sup>23,37</sup> Similarly, there are no published case reports of hematoma following supraclavicular block.

A single report of a patient who was receiving argatroban for heparin-induced thrombocytopenia and underwent an ultrasound-guided supraclavicular brachial plexus block for postoperative analgesia described good analgesic effect and no hematoma or neurologic complications.<sup>38</sup>

### *Retroclavicular brachial plexus block*

Though vascular puncture has been described during ultrasound-guided retroclavicular brachial plexus block,<sup>39</sup> there have been no reports of other bleeding complications or hematoma formation. Nevertheless, this block was only recently described and reports of bleeding complications or hematoma may therefore be under-reported. Furthermore, the blind initial needle pass with this technique does not allow for the advantage of ultrasound visualization of arteries and veins over the entire needle path.

### *Infraclavicular brachial plexus block*

The infraclavicular brachial plexus lies deep and inferior to the clavicle. While surrounding vascular structures including the axillary artery, axillary vein, and cephalic vein can routinely be anticipated, visualized, and avoided using ultrasound guidance, the risk of vascular puncture remains.

In large (> 200 patients) prospective and retrospective databases, the incidence of vascular puncture during infraclavicular block was noted to be between 0 and 6.6% with nerve stimulator guidance<sup>40–42</sup> while it was 0.7% with ultrasound guidance,<sup>43</sup> with no reports of hematoma formation.

There is only one case report of hematoma after infraclavicular brachial plexus block. This complication occurred in a patient with a history of intravenous drug use and a mechanical mitral valve placed secondary to endocarditis. After withholding anticoagulation, the patient received an ultrasound-guided infraclavicular brachial plexus block. The anticoagulation was subsequently restarted and two weeks postoperatively, the

patient presented with an axillary hematoma and two mycotic aneurysms.<sup>44</sup>

Conversely, there is one case report of a patient who underwent an ultrasound-guided infraclavicular brachial plexus block for analgesia and sympathectomy while on therapeutic heparin after hand reimplantation.<sup>45</sup> Though no bleeding resulted, it was noted that the surgeon was prepared to stop the heparin were an expanding hematoma to develop.

### *Axillary brachial plexus block*

The axillary brachial plexus is the most distal site at which all of the sensory branches of the distal upper extremity can be targeted with a single needle insertion. Vascular puncture is a risk because of the multiple axillary veins and the axillary artery, all of which lay adjacent to the nerves of the brachial plexus at the level of the conjoint tendon. Nevertheless, the site is readily compressible, thus vascular puncture is usually of little clinical consequence, as evidenced in part by the time-honoured transarterial technique of axillary brachial plexus blockade.

Only one study of 605 patients examined the occurrence of inadvertent vascular puncture in nerve stimulator-guided axillary brachial plexus blocks and reported an overall incidence of 8.4%. Nevertheless, the rate was three times higher in obese than in non-obese patients within this cohort.<sup>46</sup> Two large studies (1,346 patients in total) explored hematoma rates after transarterial axillary brachial plexus block. While one noted “no serious adverse reaction”,<sup>47</sup> the other described a 0.2% incidence of small hematomas (0–2 cm).<sup>48</sup> No other bleeding complications were noted in either study. Another trial assessed the combination of paresthesia and transarterial techniques for axillary brachial plexus block and found a 12% incidence of “axillary tenderness and bruising”.<sup>49</sup>

No studies or databases with > 200 patients have reported inadvertent vascular puncture in ultrasound-guided axillary brachial plexus block. Nevertheless, based on smaller studies (29–64 patients per group), the incidence of vascular puncture is between 0 and 15%.<sup>50–56</sup> No hematoma was recorded in any of these studies.

Hematoma formation has been noted in several studies and case reports using the paresthesia, nerve stimulation, or landmark-guided approaches.<sup>49,57–60</sup> Nevertheless, only one “minor hematoma” has been documented when using an ultrasound-guided technique.<sup>53</sup>

### *Other blocks of the upper extremity*

To date, no bleeding complications have been reported with suprascapular nerve block, axillary nerve block, or

distal blocks of the median, ulnar or radial nerves, either with or without the use of ultrasound.

#### Risk classification consensus

##### *Interscalene and supraclavicular brachial plexus block*

Despite substantial vascularity in the region, the literature review would suggest a low incidence of vascular puncture and bleeding complications. With appropriate education and training, common vascular structures may be anticipated, visualized, and avoided with ultrasound guidance.<sup>61</sup> If vascular puncture does occur, pressure can be readily applied to limit bleeding. Nevertheless, if a large expanding hematoma does occur, it could have serious consequences, including airway compromise. The panel therefore recommends that the interscalene and supraclavicular brachial plexus blocks be classified as intermediate risk for bleeding complications.

##### *Infraclavicular and retroclavicular brachial plexus block*

The infraclavicular brachial plexus lies in a richly vascular area, but the literature review suggested that bleeding complications are low. Application of direct pressure to limit hematoma formation can be challenging and may require not only anterior to posterior thoracic pressure but also lateral to medial pressure via the axilla. The panel therefore recommends that the infraclavicular and retroclavicular brachial plexus blocks be classified as intermediate risk for bleeding complications.

##### *Axillary brachial plexus block*

Although one study (involving 200 patients) of a landmark-based approach noted a 12% incidence of axillary tenderness and bruising,<sup>49</sup> hematoma formation following ultrasound-guided axillary brachial plexus block was infrequent. The panel therefore recommends that the axillary brachial plexus block be classified as low risk for bleeding complications. Despite this, it is important that caution be exercised to avoid unnecessary vessel puncture while performing blocks in this vascular rich area.

##### *Distal (median, ulnar, and radial) nerve blocks*

There are no case reports of bleeding complications following blocks of the median, radial, or ulnar nerves, as the block sites are relatively superficial and easily compressible. Ultrasound guidance may allow visualization and avoidance of these blood vessels and thus likely decreases the risk of bleeding complications. The panel therefore recommends that distal blocks of the

ulnar, median, or radial nerves be classified as low risk for bleeding complications.

#### Lower extremity blocks

##### Evidence review

With the exception of a single retroperitoneal hematoma reported in the context of a prospective series,<sup>28</sup> the literature search yielded only case reports of bleeding or aneurysmal complications after lower extremity blocks.<sup>64-72</sup> The reported complications from these articles are summarized in Table 7.

##### *Lumbar plexus block*

More than half of the reported bleeding complications after lower limb nerve blocks have occurred in the setting of loss of resistance or neurostimulation-guided lumbar plexus blocks.<sup>62-67</sup> Clinical sequelae have included psoas hematoma with lumbar plexopathy,<sup>63</sup> retroperitoneal hematoma,<sup>64-67</sup> and renal subcapsular hematoma.<sup>62</sup> In many cases where complications have occurred, the block was technically difficult and multiple attempts were required.<sup>63,65-67</sup> Furthermore, administration of anticoagulants (heparin, low molecular weight heparin) and/or acetylsalicylic acid was also noted in more than half of the patients.<sup>63-66</sup> Fortunately, in most instances, the hematoma resolved without invasive intervention or neurologic impairment. Nevertheless the resolution process was slow and required weeks<sup>66,67</sup> to months.<sup>62,63,65</sup>

##### *Femoral block*

Although the femoral nerve is superficially situated, its proximity to the femoral artery has (presumably) led to the occurrence of retroperitoneal hematoma following perineural catheter placement.<sup>27</sup> Furthermore, intraneural hematoma<sup>68</sup> has also been reported in one patient with undiagnosed factor XI deficiency after neurostimulation-guided femoral nerve block. Despite aggressive management with surgical decompression, persistent neurologic impairment was observed in both cases.<sup>27,68</sup>

##### *Other nerve blocks of the lower extremity*

Thigh hematoma and pseudoaneurysm of a collateral branch of the superficial femoral artery have been reported after anterior sciatic and adductor canal blocks, respectively.<sup>69,70</sup> The patient undergoing the anterior sciatic nerve block had received fondaparinux and the neurostimulation-guided block was reported to be

technically difficult, requiring multiple attempts [69]. While the adductor canal block was performed under ultrasound guidance, the pseudoaneurysm occurred following placement of a perineural catheter.<sup>70</sup> Although the thigh hematoma resolved spontaneously,<sup>69</sup> the pseudoaneurysm required embolization.<sup>70</sup> Fortunately, no permanent sequelae were noted following either case.

To date, the English-language literature contains no reports of major bleeding complications after lateral femoral cutaneous blocks, obturator nerve blocks, or other approaches to the sciatic nerve block. Nevertheless, the absence of evidence for complications should not be interpreted as evidence of absence of complications. For instance, although lateral femoral cutaneous blocks are performed in a superficial and avascular area, the same may not hold true for deeper procedures such as the parasacral sciatic nerve block. In fact, the latter's perceived "safety" may attest more to a lack of popularity among anesthesiologists rather than true innocuity.

#### Risk classification consensus

##### *Deep lower limb blocks*

The available literature suggests that lower extremity blocks targeting nerves or plexi situated deep to the skin and close to vital non-compressible structures (e.g., kidney, retroperitoneum, pelvic organs) be considered high risk. These areas are richly vascularized, not easily compressible in the event of vascular puncture, and the clinical diagnosis of an expanding hematoma can be difficult. The panel therefore recommends that lumbar plexus and parasacral sciatic nerve blocks be classified as high risk for bleeding complications.

In contrast, blocks that target nerves or plexi situated deep to the skin but far from vital structures carry a lower risk of significant consequences following bleeding and hematoma formation. The panel therefore recommends that transgluteal sciatic, subgluteal sciatic, anterior sciatic, obturator, and suprainguinal fascia iliaca (i.e., "bow-tie") blocks be classified as intermediate risk for bleeding complications.

##### *Superficial lower limb blocks*

Blocks targeting superficial nerves allow ease of compressibility in the event of bleeding. As such, vascular puncture occurring during performance of the femoral nerve, femoral triangle, adductor canal, lateral femoral cutaneous nerve, infrainguinal fascia iliaca, popliteal sciatic nerve, and ankle blocks should not cause significant bleeding complications if detected and treated early. The incidence of vascular puncture will also depend

on the guidance modality (e.g., neurostimulation vs ultrasound guidance). The advantage of ultrasonography to visualize normal and aberrant vessels has been highlighted for the popliteal sciatic location,<sup>71</sup> and may allow the operator to plan for a safer needle trajectory or to select an alternative approach. The risk assessment should be modified in obese patients in whom the structures may lie much deeper than usual; this increases the risk of inadvertent vascular puncture and may hinder effective compression of the bleeding site.

The panel recommends that lower extremity blocks performed close to large vessels (femoral nerve, adductor canal, and popliteal sciatic nerve blocks) be classified as intermediate risk for bleeding complications. The panel recommends that blocks of nerves in a very superficial location (lateral femoral cutaneous nerve, infrainguinal fascia iliaca, and ankle blocks) be classified as low risk for bleeding complications.

#### **Interfascial plane blocks**

##### Evidence review

The literature search identified 1,207 publications. After manual review, only reports of bleeding or aneurysmal complications and visceral or peritoneal injury were retained, yielding 16 relevant publications.<sup>72-87</sup> The reported complications from these articles are summarized in Table 8. A majority of the studies that prospectively examined complications following interfascial blocks were unclear in their approach to measurement and were excluded because data was lacking. Most reports of complications during interfascial blocks are therefore derived from case series and case reports.

##### *Transversus abdominis plane (TAP) block*

Two reports acknowledged bleeding-related complications after TAP block procedures including a case of vascular puncture<sup>79</sup> and an intramuscular hematoma in a patient with peripartum coagulopathy.<sup>81</sup> A total of four additional reports acknowledged non-bleeding but relevant complications related to TAP block procedures.<sup>76,78,79,87</sup> These included peritoneal puncture,<sup>76,79</sup> liver injury with peritonitis,<sup>78,87-90</sup> and an unknown complication in a patient with a high BMI.<sup>75</sup> When the blocks were performed before the surgical incision, complications were recognized during the subsequent laparotomy/laparoscopy. With blocks performed at the end of surgery, advanced imaging such as computed tomography (CT) scanning was required. The use of ultrasound and



blunt tip block needles during the performance of these blocks was confirmed in four of six reports. All reported complications were managed conservatively and did not require additional intervention.

#### *Ilioinguinal iliohypogastric nerve (IIN/IHG) block*

Five case reports noted complications following IIN/IHG blocks,<sup>72,74,77,80,84</sup> including one instance each of intrapelvic hematoma<sup>84</sup> and retroperitoneal hematoma,<sup>80</sup> as well as three reported cases of bowel injury.<sup>72,74,77</sup> All IIN/IHG blocks performed in these five cases employed a double-pop technique. While in the case of retroperitoneal hematoma the patient was concurrently taking antiplatelet medications, the case of intrapelvic hematoma had no history of coagulopathy or medications altering coagulation. Both these complications required a CT scan for diagnosis following signs and symptoms of pain and blood loss. The patient with retroperitoneal hematoma experienced an injury to the deep circumflex iliac artery, which required embolization, while the case of intrapelvic hematoma was managed conservatively. Of the three patients developing bowel injury, two cases were recognized intraoperatively and managed with minimal surgical intervention<sup>74,77</sup> while the third case was identified five days later following signs and symptoms of bowel obstruction and required small bowel excision.<sup>72</sup>

#### *Rectus sheath block*

Two reports noted complications secondary to rectus sheath blocks, both of which were performed using the loss of resistance technique.<sup>85,86</sup> While the complication in one report was limited to intraperitoneal injection,<sup>86</sup> the other resulted in retroperitoneal hematoma.<sup>85</sup> During this later block, blood aspiration was noted during the procedure and the block was abandoned. The patient underwent postoperative CT imaging to determine the extent of the complication but was managed conservatively without the need for any further intervention.

#### *Pectoral nerve (PECS) blocks*

Two reports noted bleeding complications following a PECS block.<sup>73,83</sup> In a randomized-controlled trial (RCT) of 127 patients receiving a PECS-1 block, three patients (2.3%) were noted to have bleeding and pectoral hematoma,<sup>73</sup> while in another observational study of PECS block, eight of 498 patients (1.6%) developed a pectoral hematoma.<sup>83</sup> Of the eight patients in this later report who developed a bleeding complication, five were on either an oral anticoagulant or an antiplatelet medication.

#### *Other newer blocks*

No published hematologic complications have been noted with the newer interfascial plane (transversalis fascia plane, serratus anterior, retrolaminar, quadratus lumborum, and erector spinae plane) blocks<sup>91,92</sup> but this may simply reflect the limited experiences with these newer techniques. Further, the manifestation of hematologic complications with these newer blocks may be varied as exemplified with the recent reporting of quadratus lumborum hematomas in a pediatric population.<sup>93</sup> One of the two patients having the complication received heparin 3.5 hr following the block while the coagulation status was not altered in the other patient. Both these complications resulted in lumbar pain out of proportion to surgical pain and manifested as bruising in the lumbar region a few days following these blocks, highlighting the delayed presentation of hematologic complications following the quadratus lumborum block.

#### *Risk classification consensus*

Although the interfascial plane blocks have been safely performed in patients receiving anticoagulation or on antiplatelet therapy, the risk of vascular or visceral injury and the related bleeding risks remain significant possibilities.

While the TAP blocks, IIN/IHG blocks, PECS block, serratus anterior blocks, and the rectus sheath blocks are superficial, serious complications such as bleeding, visceral injury, peritonitis, and hematoma have been reported in the literature. In applying the CIA scoring tool, blood vessels within the fascial plane and the viscera deeper may be deemed critical structures. Furthermore, the complications noted with many of these blocks were not immediately detected and were either recognized at laparotomy or following CT imaging for symptomatic patients. Most of the complications were managed conservatively and did not need additional interventions.

Given the risk of hematoma and visceral injury, the panel agreed that TAP blocks, rectus sheath blocks, and IIN/IHG blocks in patients at risk of bleeding should be performed using guidance techniques such as ultrasonography by personnel with adequate experience. The panel recommends that these blocks be classified as intermediate risk for bleeding complications.

The transversalis fascia plane block is very similar in anatomy and approach to a TAP block, and thus the panel recommends that it be similarly classified as intermediate risk for bleeding complications.

The quadratus lumborum block, on the other hand, is a deeper block with a needle trajectory into a non-compressible space. The risk of bleeding complications

and visceral injury may thus be considered similar to that of the lumbar plexus block, although there are sparse published data to either support or refute this. The panel therefore currently recommends that the quadratus lumborum block be classified as high risk for bleeding complications.

Pectoral nerve blocks and the other newer anterior chest wall blocks have only been described employing ultrasound guidance and the consequences of complications are at present unclear.

Based on the location of injection deep to the pectoral muscles, and the presence of nearby vascular structures such as the thoracoacromial artery, the panel recommends that these blocks be classified as intermediate risk for bleeding complications.

Bleeding complications or visceral injury with newer blocks, such as retrolaminar or erector spinae plane blocks, have not been reported. Hence, because there are no critical structures in close proximity, the panel recommends that these blocks be classified as low risk for bleeding complications.

## Truncal blocks

### Evidence review

#### *Paravertebral block*

The paravertebral space can be accessed from a number of approaches that follow anatomic landmarks or employ ultrasound guidance. The region of the paravertebral space is richly vascular with each of the intercostal nerves and vasculature travelling to some degree within this compartment. In addition, the lung and major vessels deep to the space contribute to anatomic complexity with these blocks. Paravertebral blocks are among the most widely described and reported regional procedures over many decades, with few overall bleeding complications reported.

In this review, the search strategy identified 1,574 articles, which underwent manual review. A number of large retrospective studies have reported on local experience. Three such reports totalling 3,215 blocks identified no bleeding complications.<sup>94-96</sup> Nevertheless, an additional series of 620 adult patients describe inadvertent vascular puncture in 6.8% of the procedures and superficial hematoma requiring external compression in 2.4%.<sup>97</sup>

Most bleeding complications associated with paravertebral blocks have been reported as secondary outcomes in unrelated trials. Inadvertent vascular puncture in particular has been reported in 13 publications.<sup>98-110</sup>

These were reported across a range of adult and pediatric populations, under anatomic and ultrasound guidance, during single shot and catheter blocks, and with rates in these reports of between one-in-527<sup>102</sup> and one-in-eight.<sup>105</sup> None of these cases resulted in serious bleeding outcomes, despite the presence of therapeutic anticoagulation in two reports.<sup>101,102</sup> Of note, an additional case report describes vascular puncture of a thoracic aneurysm during single shot block, fortunately without catastrophic outcome.<sup>111</sup> Superficial bleeding that did not require intervention has been reported in five publications<sup>102,112-115</sup> exclusively in procedures performed using Tuohy needles for catheter placement. Bleeding in this location may be unrecognized superficially and one case series describes five of 26 patients (who received a percutaneous catheter via an 18G Tuohy needle) developing a hematoma that was visually confirmed internally during the video-assisted thoracoscopic surgery (VATS) procedure.<sup>116</sup> No intervention was necessary in these cases. Finally, one case report describes frank pulmonary hemorrhage detected via the endotracheal tube with concurrent spinal and periaortic hematoma found on a follow-up CT scan.<sup>117</sup> This complication occurred in a patient with previous thoracotomy, leading to compromise of the paravertebral space by postsurgical scarring. The patient was managed conservatively.

Despite these reports, paravertebral blocks have been described in 13 publications as interventions specifically for anticoagulated patients. These publications include cardiac surgery patients,<sup>101,112,118,119</sup> pre-existing coagulopathies,<sup>114,120-122</sup> thrombocytopenia,<sup>123,124</sup> and antiplatelet medications.<sup>102,125,126</sup> No serious complications occurred in any of these reports.

#### *Intercostal block*

The intercostal nerves run in close approximation to the vascular bundle of the intercostal artery and vein, along the intercostal groove on the ventral caudal surface of each rib.<sup>127</sup> While the location of these structures is superficial relative to the skin, the thoracic cavity below the pleura represents a large and hidden compartment in which blood may accumulate.

The search strategy returned 1,355 articles, which were manually reviewed for relevance. Large numbers of intercostal blocks have been reported without bleeding complications. In one study, 50,097 individual blocks in 4,333 patients were described without a single bleeding complication.<sup>128</sup> Furthermore, case series and case reports have been described in anticoagulated, high bleeding risk patients without adverse outcomes.<sup>129,130</sup> Nevertheless, three case reports highlight potential risks.<sup>131-133</sup> One patient without bleeding risk factors received a series of

diagnostic single shot blocks, followed by a catheter insertion, and subsequently a final single shot anatomic-guided block. After the catheter placement, a superficial hematoma was noted and the catheter was removed. Two weeks later, the single shot injection resulted in a 1,000 mL hemothorax that required drainage followed by conservative management. The hemothorax was detected after symptoms consistent with large volume blood loss led to a thoracic CT scan.<sup>131</sup> Two additional case reports describe massive chest wall and flank hematomas that developed following intercostal nerve block in patients with impaired coagulation.<sup>132,133</sup> In both cases, the bleeding was easily visible superficially and was managed conservatively. During a series of fluoroscopic-guided intercostal steroid injections, intravascular spread was noted in two out of 26 patients but without reported bleeding complications.<sup>134</sup> Finally, during VATS in a series of 24 patients receiving intercostal catheters, local hematoma was observed when the chest was opened in two patients. Of note, pain in these patients was significantly higher in the postoperative period although no intervention for the bleeding was necessary.<sup>116</sup>

#### Risk classification consensus

##### *Paravertebral block*

The paravertebral space is a non-accessible and non-compressible space with a number of critical structures in close proximity. As such it has all the characteristics of a high-risk regional technique. In addition, bleeding within the space, or into the thoracic cavity is not readily detectable on clinical examination.<sup>116</sup> The panel therefore recommends that paravertebral blocks be classified as high risk for bleeding complications. Nevertheless, we note that numerous authors have employed this block specifically as an alternative to neuraxial blockade in patients at high risk of bleeding complications.<sup>101,102</sup> There may be circumstances where this block is an appropriate choice, even in patients at elevated risk of bleeding complications. Nevertheless this decision should be taken after careful consideration of the risk:benefit ratio and the expertise of the practitioner.

##### *Intercostal block*

Although the available literature reports only a small number of cases with bleeding complications, the degree of hemorrhage and size of hematoma formation reported in these cases is large. Furthermore, bleeding into the thoracic cavity may remain occult until hemodynamic effects from large volume blood loss are evident.<sup>131</sup> In cases where bleeding complications have been noted, conservative

management was the most common approach, although in one instance, evacuation of hemothorax was required. This risk of intrathoracic bleeding combined with difficulty in compressing the intercostal space increases the potential for negative outcome. While the distance from the neuraxis may presumably reduce the impact of any hematoma on the critical structures in this region, no evidence exists to guide clinical decisions based on this consideration. As a result of these issues, the panel recommends that intercostal blocks be classified as intermediate risk for bleeding complications.

#### Discussion

The consensus advisory recommendations are summarized in Table 3. Relevant key information from the cited references is summarized in Tables 4–9 according to anatomic regions. In recognition of the lack of systematic studies assessing the risk of bleeding complications as a primary outcome, data on bleeding complications reported as secondary outcomes in RCTs or cohort studies were assigned the same level of evidence as case report data.

In patients with an elevated risk of bleeding complications due to coagulopathy, anticoagulation, or antithrombotic therapy, the panel generally recommends the following:

- Low risk: The risk of bleeding complications is expected to be low. Although rare events cannot be excluded, they are expected to be easily managed.
- Intermediate risk: The risk of bleeding complications is a genuine possibility. The decision to perform a block should be made on a case-by-case basis after evaluating the risks and benefits of the block. The procedure should be performed by experienced personnel with additional monitoring of the block technique and potential complications. Monitoring aids should include ultrasound guidance for the block performance. The panel also recommends that these blocks be performed in a manner that would aid in early recognition of the complication. For example, TAP blocks or rectus sheath blocks may be performed preoperatively or presurgically rather than postoperatively, as the hematologic complication may be recognized during laparotomy or laparoscopy. The panel also recommends that intermediate risk blocks be monitored for hemodynamic changes and any bleeding manifestations following the procedure until deemed necessary. Routine monitoring such as ultrasound assessment of the block site for any fluid collections over time, impedance monitoring,<sup>135</sup> or inclusion of a vascular marker in the local anesthetic mixture may be

additional useful aids, but whether they improve the safety profile of block performance is currently unknown.

- **High risk:** The bleeding complications may be associated with significant morbidity or may be difficult to detect. Given the risk of bleeding complications and associated sequelae with the procedure, these blocks should be reconsidered if the patient has an elevated bleeding risk—i.e., these blocks should be avoided in these patients except in exceptional circumstances where the benefits clearly outweigh the increased complication risk.

High-quality evidence is lacking, therefore the recommendations of this practice advisory are largely contingent on expert opinion rather than being evidence based. Indeed, the level of evidence for the bleeding risks and complications for most procedures is either very low or nonexistent. This may be in part due to the rarity of these events, making studies evaluating them hard to design. Apart from the rarity of trials evaluating complication rates as a primary outcome measure, there is also a significant reporting and publication bias for case reports especially those which do not report positive outcomes.<sup>136,137</sup> This often requires non-traditional data collection methods and analysis leading to potentially very poor external validity.<sup>138</sup> Such prospective studies, while important to the quality improvement perspective of our practice are unfortunately sparse in regional anesthesia literature. One of the reasons for the rare occurrence of bleeding complications may be the enhanced safety from the implementation of guidelines in the management of patients with altered coagulation undergoing regional anesthesia. Nevertheless, one of the potential limitations of this work was that we chose our literature search to include only MEDLINE and EMBASE. While we believed that it would encompass the majority of the available literature, one may argue that additional database searches potentially strengthen the evidence for our recommendations. Given the absence of available clinical data, whether or not such a broader search strategy would have increased the number of unique references remains uncertain.<sup>139,140</sup>

## Conclusions

Bleeding complications following regional peripheral nerve and interfascial plane blocks are rare, but when present, they may lead to significant patient morbidity and the need for further investigations and interventions. The risk of bleeding complications following regional anesthesia procedures depends on the degree of trauma

produced by the needle, patient coagulation status, and the type of block. The present advisory describes the risk and subsequent clinical implications from the perspective of the individual type of block. The risk of bleeding complications and the subsequent sequelae vary between blocks. This needs to be weighed against the potential benefits, while offering these procedures on a case-by-case basis. The paucity of evidence in anticoagulated patients does not necessarily translate into a lower risk of bleeding complications as most of these blocks will not routinely be offered to such patients given existing regional anesthesia guidelines.

The best efforts of the panel were employed to categorize bleeding risk for peripheral regional anesthesia procedures using published evidence combined with the panel's clinical experience. Nevertheless, the actual risk of a given procedure is indeterminate and the quality of published evidence for most blocks remains low. The ratings are in part based on theoretical principles and consensus because sufficient evidence from quality-controlled studies was absent. The risks categories determined by applying this methodology should therefore not be construed as absolute and the consensus will be subject to periodic revision as warranted by evaluation of the evolving knowledge base. Hence, it is critical to reemphasize that many recommendations stated here are based on limited or nonexistent clinical data. As such, interpretation of the literature by this panel may differ from that of other equally qualified experts. More importantly, the clinician must exercise their clinical judgement when determining the risks and benefits in individual patient cases and how to proceed should inadvertent vascular puncture be noted.

Given these facts, readers of this consensus advisory should be reminded that these recommendations are not to be defined as a standard of care but rather serve as a resource for clinicians assessing the risk and benefits of regional anesthesia in management of their patients.

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### Appendix Summary of survey results using bleeding risk score from seven panelists (critical, intervention, and assess) system

Body region	Blocks	CIA percentages (%) n=7		
		Low (score =0)	Intermediate (score = 1)	High (score 2 or 3)
<b>Head and neck</b>	Occipital nerve blocks	100.0	0.0	0.0
	Superficial cervical plexus block	71.4	28.6	0.0
	Deep cervical plexus	14.3	14.3	71.4
<b>Above clavicle</b>	Interscalene brachial plexus block	28.6	71.4	0.0
	Supraclavicular brachial plexus block	14.3	57.1	28.6
<b>Below clavicle</b>	Infraclavicular brachial plexus block	14.3	42.9	42.9
	Axillary brachial plexus block	85.7	14.3	0.0
	Median, radial, ulnar nerve block	100.0	0.0	0.0
<b>Lumbar plexus</b>	Lumbar plexus block	0.0	0.0	100.0
	Femoral nerve block	100.0	0.0	0.0
	Lateral femoral cutaneous nerve block	100.0	0.0	0.0
	Obturator nerve block	71.4	14.3	14.3
	Adductor canal	85.7	14.3	0.0
	Nerve block			
<b>Sacral plexus</b>	Proximal sciatic nerve block	0.0	42.9	57.1
	Popliteal nerve blocks	100.0	0.0	0.0
<b>Ankle</b>	Ankle block	100.0	0.0	0.0
<b>Interfascial plane</b>	Rectus sheath	71.4	28.6	0.0
	TAP blocks	71.4	28.6	0.0
	TAP subcostal	71.4	28.6	0.0
	Quadratus lumborum blocks	14.3	0.0	85.7
	Transversalis fascia block	28.6	28.6	42.9
	Erector spinae plane block	71.4	28.6	0.0
	Pectoralis nerve (Pecs) 1	71.4	28.6	0.0
	Pectoralis nerve (Pecs) 2	57.1	42.9	0.0
	Serratus anterior plane block	71.4	14.3	14.3
<b>Truncal</b>	Paravertebral block	0.0	0.0	100.0
	Intercostal block	14.3	57.1	28.6

CIA = critical, intervention, and assess; TAP = transversus abdominis plane block.

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