Recommendations for Anatomical Structures to Identify on Ultrasound for the Performance of Intermediate and Advanced Blocks in Ultrasound-Guided Regional Anesthesia

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Running Head

Structures to identify in regional anesthesia

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Abbreviations

ASRA	-	American Society of Regional Anesthesia and Pain Medicine
ESRA	-	European Society of Regional Anaesthesia & Pain Therapy
RA-UK	-	Regional Anaesthesia UK
UGRA	-	Ultrasound-guided regional anesthesia
IPACK	-	Infiltration between popliteal artery and capsule of knee

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Figures and Tables

Three figures and four tables

Declarations of interest

Alain Delbos, Yavuz Gurkan, Clara A Lobo, Luis Fernando Valdés-Vilches, Thomas Volk and Morné Wolmarans are members of the Executive Board of the European Society of Regional Anaesthesia & Pain Therapy (ESRA).

Nabil M Elkassabany, Rajnish K. Gupta, and Meg A Rosenblatt are members of the Board of Directors of the American Society of Regional Anesthesia & Pain Medicine (ASRA). Edward R. Mariano, Stavros Memtsoudis, and Eric Schwenk sit on ASRA Committees.

Toby Ashken, Ashwani Gupta, Nat Haslam, David F Johnston, Rachel J Kearns, Alan JR Macfarlane, Amit Pawa, Maria Paz Sebastian, Athmaja Thottungal, Lloyd Turbitt, Simeon West, Jonathan Womack are members of the Board of Regional Anaesthesia UK (RA-UK).

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Ethical Approval

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Abstract

Recent recommendations describe a set of core anatomical structures to identify on ultrasound for the performance of basic blocks in ultrasound-guided regional anesthesia (UGRA). This project aimed to generate consensus recommendations for core structures to identify during the performance of intermediate and advanced blocks. An initial long-list of structures was refined by an international panel of key opinion leaders in UGRA over a three-round Delphi process. All rounds were conducted virtually and anonymously. Blocks were considered twice in each round: for "orientation scanning" (the dynamic process of acquiring the final view) and for "block view" (which visualizes the block site and is maintained for needle insertion/injection). A "strong recommendation" was made if ≥75% of participants rated any structure as "definitely include" in any round. A "weak recommendation" was made if >50% of participants rated it as "definitely include" or "probably include" for all rounds but the criterion for strong recommendation was never met. Structures which did not meet either criterion were excluded. Forty-one participants were invited and 40 accepted; 38 completed all three rounds. Participants considered the ultrasound scanning for 19 peripheral nerve blocks across all three rounds. Two hundred and seventy-four structures were reviewed for both orientation scanning and block view; a "strong recommendation" was made for 60 structures on orientation scanning and 44 on the block view. A "weak recommendation" was made for 107 and 62 structures respectively. These recommendations are intended to help standardize teaching and research in UGRA, and support widespread and consistent practice.

Introduction

There has been recent momentum to increase standardization in ultrasound-guided regional anesthesia (UGRA).[1,2] Successful UGRA is dependent upon the accurate identification of anatomical structures on ultrasound imaging.[3,4] However, until now, there has been a lack of consistency on the recommended structures to identify on ultrasound for the majority of peripheral nerve blocks.[1] We recently presented an international expert consensus on the recommended anatomical structures to identify on ultrasound for basic blocks.[1] A modified Delphi technique was employed to produce "strong recommendations" and "weak recommendations" for orientation scanning and the block view of seven basic peripheral nerve blocks. The seven basic blocks were the suggested "Plan A" blocks in the editorial by Turbitt et al. (2020), in which the authors asserted that "*standardised ultrasound-guided approaches should be established for all basic block techniques"*.[5] However, they also acknowledged that "*the anaesthetist may need a backup regional anaesthesia option (Plan B)*", with the specialist in regional anesthesia possibly needing "*even a Plan C and D depending on the patient and situation*". Turbitt et al. refer to these intermediate and advanced level blocks collectively as "Plan BCD" blocks.[5]

The aim of this project was to use the same modified Delphi process as in the prior basic blocks project to generate consensus, among an international group of experts, on the minimum anatomical structures to identify on ultrasound for the performance of 20 intermediate and advanced (Plan BCD) blocks in UGRA.[1] For each block both "orientation scanning" (the dynamic process of acquiring the final view) and the "block view" (which visualizes the block site and is maintained for needle insertion/injection) were considered.

The recommendations contained herein do not define standard of care. They are not intended to replace clinical judgment. In the imperfect setting of heterogeneity of the data, limited data, controversial topics, and bias inherent to expert opinion, compliance with the recommendations may not result in improved outcomes compared to alternative therapies consistent with personalized medicine.

Methods

This project was conducted by Regional Anaesthesia UK (RA-UK) and is endorsed by both the American Society of Regional Anesthesia and Pain Medicine (ASRA) and the European Society of Regional Anaesthesia & Pain Therapy (ESRA). A summary of the methodology is presented below (a full description is available in Supplemental File A).

The peripheral nerve blocks included were drawn from the BCD blocks described in the editorial by Turbitt et al.[5] This list was reviewed by the steering group (TA, BB, JB, AJRM, AP, LT) and refined where greater specificity was thought to be required (e.g., inclusion of both anterior and lateral approaches to the quadratus lumborum block). The final list of 20 blocks initially considered is shown in table 1.

Table 1. Intermediate and advanced blocks considered

Shoulder	Superior trunk block Axillary nerve block Suprascapular nerve block
Below shoulder	Supraclavicular block Infraclavicular block
Hip	Fascia iliaca block Lumbar plexus block
Knee	Infiltration between popliteal artery and capsule of knee (IPACK)**
Foot and ankle	Tibial nerve block* Deep peroneal nerve block* Superficial peroneal nerve block* Sural nerve block* Saphenous nerve block* Subgluteal sciatic nerve block* Parasacral sciatic nerve block*
Chest wall	Paravertebral block Deep or superficial serratus anterior plane blocks*** Interpectoral/pectoserratus plane blocks***
Abdominal midline	Lateral quadratus lumborum block*

	Anterior quadratus lumborum block*

*Blocks determined by steering group (original Plan BCD description listed “Ankle blocks”, “Proximal sciatic nerve block” and “Quadratus lumborum blocks”)[5]
**Original Plan BCD description listed “Femoral nerve block +/- IPACK block”. Femoral nerve block was not considered as it has been covered in the previous basic (Plan) A project[1]
***Block name changed as per ASRA-ESRA nomenclature recommendation[2]

The Ultrasound Regional Anaesthesia Interpretation Skill Evaluation study team (URAISE; Imperial College, London) undertook a scoping review of the literature in November 2020, using PUBMED, to develop an initial list of anatomical structures relevant to each block. Additional anatomical structures were added if deemed to be potentially relevant by any member of the steering committee. The completed long-list contained 287 structures (supplemental file A).

As with the previous consensus process, both orientation scanning and the block view elements of ultrasound scanning (as defined above) were considered.[1] Twenty-eight UK-based key opinion leaders in UGRA were invited to take part. To achieve international consensus, a further 13 invitations were extended to ASRA and ESRA representatives. A modified Delphi technique was once again employed, with rating rounds conducted using Google Forms.[1] Participants reviewed the long-list of anatomical structures for each block and were asked to rate whether items should be included as a core (minimum) structure that is essential to identify on orientation scanning by a non-expert. The same structures were then reviewed again, this time rating whether each should be included as core for the block view. Ratings were performed on the following 4-point Likert scale:

- Definitely include
- Probably include
- Probably exclude
- Definitely exclude

As in the prior project, structures rated as “definitely include” by ≥75% participants were accepted for inclusion (and not rated again in further rounds).[1] Structures which did not meet

this criterion but rated as either “definitely include” or “probably include” by more than half (50%) of participants were retained for the next round. Structures which did not meet either of these criteria were excluded.

Rating results were shared with participants after every round, including a breakdown of the Likert scoring for each structure, its overall outcome (included/retained for next round/excluded) and any alternative terminology/new structures suggested. In the following round, participants were asked to rate the remaining structures. The same thresholds were applied and any new terminology/structures, suggested in the previous round, were added to the relevant list.

After the three rounds, the structures which had met the criteria for inclusion were put forward as “strong recommendations”. Structures which did not meet this criteria, but >50% of participants had rated definitely include or probably include over all three rounds, were put forward as “weak recommendations”. The final list of “strong recommendations” and “weak recommendations” was shared with participants who had completed all three rating rounds, with feedback considered by the steering group and discussed below.

Results

Forty participants accepted an invitation to take part (from 41 invited; all accepted from the UK and ESRA, six acceptances from seven invitations to ASRA members). Thirty-eight out of 40 participants (95%) completed the first rating round for 287 structures (for both phases of scanning) across 20 nerve blocks. Free text feedback included significant reservations from many panelists over inclusion of the lumbar plexus block given its technical difficulty and unsuitability for the non-expert regional anesthesia practitioner. Many participants also commented that there were a number of different approaches to the lumbar plexus block which made answering the survey very difficult. Additionally, it was clear to the steering group that participants had rated structures for the lumbar plexus block based on a number of different approaches (with some structures already included/excluded). For these reasons, it was decided to exclude this block from the remainder of the project.

Following the exclusion of the lumbar plexus block from further consideration, 265 structures had been rated (for both phases of scanning) for 19 blocks in round one. Fifty-five and 41 structures were included for orientation scanning and the block view respectively. One hundred and thirty-one and 73 structures were retained for the next round, whilst 79 and 151 were excluded. Feedback identified a total of nine new structures (in seven blocks) to be added for rating in the second round. Following participant feedback, one terminology change was made: "divisions/cords of the brachial plexus" was replaced by "trunks/divisions of the brachial plexus" for both the suprascapular nerve block and the supraclavicular level brachial plexus block.

Participants sought greater clarity on the specific approach and/or probe orientation for four blocks. The following clarifications were provided with the invitation for the second round:

- Axillary nerve block: level of block is at the proximal humerus
- Suprainguinal fascia iliaca block: approach is that described by Hebbard[6]
- IPACK: posteromedial approach of Sinha[7]
- Mid-thoracic paravertebral block: orientation is paramedian sagittal.

The rating outcomes of round one and definitions for each block are reported in supplemental file B.

The second round was completed by all 38 of the invited participants (100%). In total 222 structures were rated. The number of included structures increased for both orientation scanning and block view, to 58 and 42 structures respectively. Twenty-one and eight structures were excluded for orientation scanning and the block view, increasing the totals to 100 and 159, respectively. Thus, 116 and 73 structures were retained for the final round. No new structures were added. No further clarifications were made to clarify block approaches or probe orientation. Further detail for the outcome of round 2 can be seen in supplemental file C.

In round three, all 38 participants (100%) again completed the rating. A total of 189 structures were rated in the third and final round. A further two structures reached the threshold for inclusion in both orientation scanning and the block view. Seven and nine structures were excluded for orientation scanning and the block view respectively. Further detail for the outcome of round three can be seen in supplemental file D.

Overall, 274 anatomical structures were considered, for 19 blocks, by participants from France, Germany, Portugal, Spain, Turkey, the UK and the USA. After three rounds of rating by a panel of 38 international participants, 60 (21.9%) structures had reached the pre-determined threshold to be "strong recommendations" for identification on orientation scanning and 44 (16.1%) structures for the block view. A further 107 (39.1%) structures reached the pre-determined threshold to be "weak recommendations" on orientation scanning and 62 (22.6%) for the block view. One hundred and seven structures (39.1%) were excluded for orientation scanning and 168 (61.3%) structures for the block view. A total of nine structures were suggested by the Delphi participants (in the first round, none were added thereafter). Of these structures added, two became weak recommendations for orientation scanning but all nine were excluded for the block view. A summary of the number of structures allocated to "included", "retained" and "excluded" after each rating round can be seen in supplemental file E. Tables 2-4 show the final "strong recommendations" and "weak recommendations". Figures 1-3 show the strong recommendation structures for the block view of each Plan BCD Block.

Table 2. Final "strong recommendations" and "weak recommendations": upper limb blocks

Block and scan	Strong recommendations	Weak recommendations
Superior (upper) trunk block: orientation scanning	Upper trunk of brachial plexus	Anterior scalene
		Middle scalene
		Middle trunk of brachial plexus
		Subclavian artery
		1st rib
		C5 transverse process
		C6 transverse process
		Sternocleidomastoid
		C5 nerve root
		C6 nerve root
		C7 nerve root
		Suprascapular nerve
		Dome of pleura
		Prevertebral fascia
Superior (upper) trunk block: block view	Upper trunk of brachial plexus	Anterior scalene
		Middle scalene
		Middle trunk of brachial plexus
Block and scan	**Strong recommendations**	**Weak recommendations**
Axillary nerve block: orientation scanning	Posterior circumflex humeral artery	Deltoid
	Axillary nerve	Teres minor
	Humerus (shaft)	Humerus (head)
		Triceps (long head)
Axillary nerve block: block view	Posterior circumflex humeral artery	Deltoid
	Axillary nerve	Teres minor
	Humerus (shaft)	
Block and scan	**Strong recommendations**	**Weak recommendations**

Suprascapular nerve block – anterior approach: orientation scanning	Suprascapular nerve	Subclavian artery
	Upper trunk of brachial plexus	Inferior belly of omohyoid
		Anterior scalene
		Middle scalene
		Suprascapular artery
		1st rib
		C6 transverse process
		Sternocleidomastoid
		Middle trunk of brachial plexus
		Trunks/divisions of brachial plexus
		C5 nerve root
		C6 nerve root
Suprascapular nerve block – anterior approach: block view	Suprascapular nerve	Subclavian artery
		Inferior belly of omohyoid
		Anterior scalene
		Middle scalene
		Upper trunk of brachial plexus
Block and scan	**Strong recommendations**	**Weak recommendations**
Infraclavicular level brachial plexus block: orientation scanning	Axillary artery	Ribs
	Pectoralis major	Pleura
	Pectoralis minor	
	Lateral cord of brachial plexus	
	Medial cord of brachial plexus	
	Posterior cord of brachial plexus	
	Axillary vein	

Infraclavicular level brachial plexus block: block view	Axillary artery	Axillary vein
	Pectoralis major	
	Pectoralis minor	
	Lateral cord of brachial plexus	
	Medial cord of brachial plexus	
	Posterior cord of brachial plexus	
Block and scan	**Strong recommendations**	**Weak recommendations**
Supraclavicular level brachial plexus block: orientation scanning	Subclavian artery	Upper trunk of brachial plexus
	1st rib	Middle trunk of brachial plexus
	Trunks/divisions of the brachial plexus	Lower trunk of brachial plexus
	Pleura	Transverse cervical artery
		Dorsal scapular artery
		Anterior scalene
		Middle scalene
Supraclavicular level brachial plexus block: block view	Subclavian artery	Upper trunk of brachial plexus
	1st rib	Middle trunk of brachial plexus
	Trunks/divisions of the brachial plexus	Lower trunk of brachial plexus
	Pleura	

Table 3. Final "strong recommendations" and "weak recommendations": lower limb blocks

Block and scan	Strong recommendations	Weak recommendations
Suprainguinal fascia iliaca block – Hebbard's approach: orientation scanning	Fascia iliaca	Deep circumflex iliac artery
	Iliacus	Sartorius
	Internal oblique	Femoral artery
		Ilium (anterior superior iliac spine)
		Ilium (anterior inferior iliac spine)
		Femoral nerve
		Peritoneum
		Intra-peritoneal contents
		External oblique
Suprainguinal fascia iliaca block – Hebbard's approach: block view	Fascia iliaca	Deep circumflex iliac artery
	Iliacus	Internal oblique
		Sartorius
Block and scan	**Strong recommendations**	**Weak recommendations**
IPACK – Sinha's approach: orientation scanning	Popliteal artery	Popliteal vein
	Femur (popliteal surface)	Femoral condyles
		Tibial nerve
		Common peroneal (fibular) nerve
		Posterior capsule of knee joint
		Sciatic nerve

		Sciatic nerve where elements (tibial and common peroneal (fibular)) diverge
IPACK– Sinha's approach: block view	Popliteal artery	Popliteal vein
	Femur (popliteal surface)	Femoral condyles
		Tibial nerve
		Common peroneal (fibular) nerve
		Posterior capsule of knee joint
Block and scan	**Strong recommendations**	**Weak recommendations**
Subgluteal sciatic nerve block: orientation scanning	Sciatic nerve	Quadratus femoris
	Femur (greater trochanter)	Biceps femoris
	Ischium (ischial tuberosity)	
	Gluteus maximus	
Subgluteal sciatic nerve block: block view	Sciatic nerve	Femur (greater trochanter)
		Ischium (ischial tuberosity)
		Gluteus maximus
		Quadratus femoris
Block and scan	**Strong recommendations**	**Weak recommendations**
Parasacral sciatic nerve block: orientation scanning	Gluteus maximus	Inferior gluteal artery
	Sciatic nerve	Ilium (posterior superior iliac spine)
	Ilium (greater sciatic notch/foramen)	Gluteus medius
	Piriformis	Sacral plexus
		Sacrum
Parasacral sciatic nerve block: block view	Gluteus maximus	Ilium (greater sciatic notch/foramen)

	Sciatic nerve	Piriformis
Block and scan	**Strong recommendations**	**Weak recommendations**
Tibial nerve block: orientation scanning	Posterior tibial artery	Posterior tibial vein(s)
	Tibial nerve	Flexor digitorum longus
	Tibia (posterior border of medial malleolus)	Flexor hallucis longus
		Tibialis posterior
		Achilles tendon
Tibial nerve block: block view	Posterior tibial artery	Posterior tibial vein(s)
	Tibial nerve	Tibia (posterior border of medial malleolus)
		Flexor digitorum longus
		Flexor hallucis longus
Block and scan	**Strong recommendations**	**Weak recommendations**
Deep peroneal nerve: orientation scanning	Dorsalis pedis artery (anterior tibial artery above ankle joint)	Anterior tibial vein(s)
	Deep peroneal (fibular) nerve	Extensor hallucis longus
	Tibia	
Deep peroneal nerve: block view	Dorsalis pedis artery (anterior tibial artery above ankle joint)	
	Deep peroneal (fibular) nerve	
	Tibia	
Block and scan	**Strong recommendations**	**Weak recommendations**
Superficial peroneal nerve: orientation scanning	Superficial peroneal (fibular) nerve	Peroneus brevis
	Fibula (lateral surface/anterior border)	Extensor digitorum longus
		Deep investing fascia of leg (crural fascia)
		Anterior intermuscular septum

Superficial peroneal nerve: block view	Superficial peroneal (fibular) nerve	Peroneus brevis Extensor digitorum longus Deep investing fascia of leg (crural fascia) Anterior intermuscular septum Fibula (lateral surface/anterior border)
Block and scan	**Strong recommendations**	**Weak recommendations**
Sural nerve block: orientation scanning	Small (short) saphenous vein Sural nerve	Peroneus brevis Achilles tendon Fibula (posterior border) Deep investing fascia of leg (crural fascia)
Sural nerve block: block view	Small (short) saphenous vein Sural nerve	Peroneus brevis Achilles tendon
Block and scan	**Strong recommendations**	**Weak recommendations**
Saphenous nerve block: orientation scanning	Great (long) saphenous vein Tibia (subcutaneous medial surface/anterior border & medial malleolus)	Saphenous nerve
Saphenous nerve block: block view	Great (long) saphenous vein	Saphenous nerve Tibia (subcutaneous medial surface/anterior border & medial malleolus)

Table 4. Final "strong recommendations" and "weak recommendations": trunk blocks

Block and scan	Strong recommendations	Weak recommendations
Mid-thoracic paravertebral block: orientation scanning	Transverse process (thoracic vertebrae)	Erector spinae muscle group
	Superior costotransverse ligament	Trapezius
	Pleura	Rhomboid major
	Rib (head/neck)	Intercostal muscles Posterior (internal) intercostal membrane
Mid-thoracic paravertebral block: block view	Transverse process (thoracic vertebrae)	Erector spinae muscle group
	Superior costotransverse ligament	Rib (head/neck)
	Pleura	
Block and scan	**Strong recommendations**	**Weak recommendations**
Deep or superficial serratus anterior plane block (formerly serratus anterior plane block): orientation scanning	Ribs	Thoracodorsal artery
	Serratus anterior	Intercostal muscles
	Pleura	Pectoralis major
	Latissimus dorsi	Pectoralis minor
Deep or superficial serratus anterior plane block (formerly serratus anterior plane block): block view	Ribs	Thoracodorsal artery
	Serratus anterior	Intercostal muscles
	Pleura	Latissimus dorsi
Block and scan	**Strong recommendations**	**Weak recommendations**
Interpectoral / pectoserratus plane blocks (formerly known as PECS block I and II): orientation scanning	Pectoralis major	Pectoral branch of thoracoacromial artery

	Pectoralis minor Rib 3 Pleura	Serratus anterior Intercostal muscles Rib 2 Rib 4
Interpectoral / pectoserratus plane blocks (formerly known as PECS block I and II): block view	Pectoralis major	Pectoral branch of thoracoacromial artery
	Pectoralis minor Rib 4	Serratus anterior Intercostal muscles Rib 3 Pleura
Block and scan	**Strong recommendations**	**Weak recommendations**
Lateral quadratus lumborum block (formerly known as QL1, includes posterior tap block): orientation scanning	Quadratus lumborum	Thoracolumbar fascia
	Internal oblique External oblique Transversus abdominis	Transversalis fascia Peritoneum Psoas major Pre-peritoneal fat
Lateral quadratus lumborum block (formerly known as QL1, includes posterior tap block): block view	Quadratus lumborum	Thoracolumbar fascia
	Internal oblique	Transversalis fascia Peritoneum External oblique Transversus abdominis
Block and scan	**Strong recommendations**	**Weak recommendations**
Anterior quadratus lumborum block (formerly known as QL3, transmuscular): orientation scanning	Quadratus lumborum	Transverse process of L3
	Psoas major	Transverse process of L4 Erector spinae muscle group

		Peritoneum Pre-peritoneal fat Thoracolumbar fascia External oblique Internal oblique Transversus abdominis Kidney
Anterior quadratus lumborum block (formerly known as QL3, transmuscular): block view	Quadratus lumborum	Transverse process of L3
	Psoas major	Transverse process of L4 Erector spinae muscle group Peritoneum Pre-peritoneal fat Thoracolumbar fascia

Discussion

The results of this international consensus project establish standardized ultrasound scanning methodology for a set of intermediate and advanced procedures in ultrasound-guided regional anesthesia. This follows recent attempts, notably by El-Boghdadly et al. and Bowness et al., to standardize practice in UGRA.[1,2] Variability in practice can hinder training, practice and research, and limit adoption of UGRA techniques (particularly by non-experts).[2,5] Recommendations in this manuscript are intended to facilitate non-experts in learning the techniques and help increase adoption of standardized UGRA practice.

In our earlier basic (Plan A) blocks project, "strong consensus" (i.e., a "strong recommendation" to include or to exclude the structure) was reached for 71.9% structures on orientation scanning and 84.4% for the block view. In this project, the figures were 60.9% and 77.4% respectively. For orientation scanning, of the 107 "weak recommendation" structures (i.e., those structures which did not reach "strong consensus"), 45 (42.1%) pertained to just four blocks (upper/superior trunk block; suprascapular block; suprainguinal fascia iliaca block; and anterior quadratus lumborum block). Similarly, for the block view, of the 62 "weak recommendation" structures, 31 (50%) related to just six blocks (suprascapular block; IPACK; superficial peroneal nerve block; interpectoral or pectoserratus plane block; the lateral quadratus lumborum block; and the anterior quadratus lumborum block). Many of these blocks are relatively recently described and some are rarely employed by practitioners without significant domain expertise. As such it may be reasonable to expect that expert participants may display greater variability in practice, less conviction in their judgement, and have greater difficulty in recommending which structures should be seen.

The invitation to take part listed the blocks under consideration and the steering group acknowledged that not all participants would regularly perform all 19 intermediate/advanced blocks in their routine clinical practice. Communication during the project rounds also emphasized this, saying "*we recognize that it is very unlikely that all expert respondents will regularly perform all blocks in this Delphi. Where a block is one that is less familiar to you, we still greatly value your opinion based on anatomical knowledge and the principles of UGRA*." During the Delphi process, five out of 38 (13.2%) participants commented that they had not performed/did not regularly practice one or more of the blocks under consideration, and thus did not consider themself an expert in that specific block. Specifically, three participants (out of 38; 7.9%) stated this for parasacral sciatic block; 2 participants (out of 38;

5.3%) stated this for anterior quadratus lumborum block; and 1 participant (out of 38; 2.6%) stated this for each of the axillary nerve block, IPACK, deep/superficial serratus anterior plane blocks, interpectoral/pectoserratus plane blocks and lateral quadratus lumborum block. These comments have been discussed with the relevant participants after each round to ensure they felt it was appropriate to include their responses based on their robust anatomical knowledge and their position as an expert in the field of UGRA (rather than as an expert in any given block).

As with the basic (Plan A) blocks project, the focus of this work was to identify a set of core (minimum) structures to identify on ultrasound to aid consistency in education, research and practice. The list of recommendations, particularly "strong recommendations", is not exhaustive and it is advisable to examine the block view ultrasound images and the needle trajectory to avoid needle trauma of structures such as aberrant blood vessels and nerves. In both studies, participants frequently mention the use of Doppler in relation to blood vessels and the practice of compressing veins to avoid venous puncture and associated bleeding or intravascular injection. Again, some participants questioned whether it was essential to be able to identify structures (especially muscles) by name or whether it was adequate for non-expert practitioners to be able to simply recognize their presence. However, naming key anatomical structures (including muscles where necessary) aids accurate structure identification when effectively teaching blocks, helps facilitate optimum clinical practice, and enables meaningful dialogue in academic literature.

The authors acknowledge that experts may have strong and informed views on precise practice for any of the blocks under consideration in this project and will bring substantial experience to their practice and teaching. Practitioners – whether expert or non-expert – may also feel that they are able to identify many additional structures that are not listed in our recommendations. The list of structures outlined in this expert consensus opinion are intended as a minimum (not maximum) standard, to help training and aid consistency in practice, and thus empower the non-expert to deliver these blocks. This composite knowledge could also be used to shape formal aspects of training and assessment in UGRA, such as the construct of questions in the American Board of Anesthesiology objective structures clinical exams. Furthermore, such expert opinion could be used to steer the development of the specialty. As with ultrasound itself, new technologies are emerging that will influence clinical practice. One such example is that of artificial intelligence, with devices which can

highlight anatomical structures of interest on ultrasound in real time.[8,9] These devices have shown early promise in supporting the practice of non-experts in UGRA, though it will be important that their development is informed by a spectrum of professional judgement and feedback.[10,11]

The 4-point Likert scale was used to quantify the subjective opinion, with the even number of potential responses intentionally chosen to require participants to decide on inclusion or exclusion of each structure. There was no in-person or virtual teleconference to discuss individual structures. This reflects the methodology of the recent Plan A project[1] and it remains the view of the steering committee that such a forum can lead to a disproportionate weighting of a small number of participants' views. A limitation of this project is that the choice of blocks considered was not objective: the blocks under consideration was derived from Turbitt et al.'s 2020 editorial.[5] Some of the approaches to these blocks were determined by the steering group. Additionally, for reasons cited above, lumbar plexus block was excluded after the first round of voting. A further limitation is that, of the 38 participants, 27 (71%) were UK based and not all countries are represented (though this was a pragmatic choice as such a number of participants would likely make the methodology difficult to manage). Further, the authors recognize the predominance of male participants (29/38; 76%) over female (9/38; 24%).

UGRA has evolved rapidly and continues to do so; many new techniques have been described in the past decade, particularly the fascial plane blocks.[12] Many of these newer blocks are considered in this project. It would be appropriate to update these recommendations in the future. Given that some of the blocks considered are also performed less frequently, even by experts, it may be appropriate to consider sub-committees to consider some of the more rarely performed blocks. Further work and involvement of other key opinion leaders in UGRA (including those beyond Europe and the USA) may validate the recommendations made here and help to reach definitive conclusions on the anatomical structures that did not reach a strong consensus. Additionally, this project did not consider ultrasound guided approaches to neuraxial blocks, which could also benefit from this approach.

Conclusion

Using a modified Delphi process and a panel of international participants, we have produced recommendations on the minimum anatomical structures that should be identified on ultrasound scanning for 19 intermediate and advanced (Plan BCD) blocks. This RA-UK project, endorsed by ASRA and ESRA, intends to facilitate consistent practice, teaching and research, and encourage adoption of these intermediate and advanced blocks.

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Manuscript preparation: TA, JB

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Figure Legends

Figure 1:

Block View for the Upper Limb Plan BCD Blocks: Anatomical structures meeting criteria for strong recommendation

Legend: AA axillary artery; **AxN** axillary nerve; **BP** brachial plexus; **LC** lateral cord of brachial plexus; **MC** medial cord of brachial plexus; **P** pleura; **PC** posterior cord of brachial plexus; **PCA** posterior circumflex artery; **PMa** pectoralis major; **PMi** pectoralis minor; **R1** 1st rib; **SA** subclavian artery; **SupN** suprascapular nerve; **ST** superior trunk of brachial plexus.

Figure 2:

Block View for the Lower Limb Plan BCD Blocks: Anatomical structures meeting criteria for strong recommendation

Legend: DPA dorsalis pedis artery (anterior tibial artery above ankle joint); **DPN** deep peroneal (fibular) nerve; **F** femur; **FI** fascia iliaca; **GM** gluteus maximus; **GSV** great saphenous vein; **IM** iliacus; **PA** popliteal artery; **PTA** posterior tibial artery; **ScN** sciatic nerve; **SPN** superficial peroneal (fibular) nerve; **SSV** short saphenous vein; **SuN** sural nerve; **TN** tibial nerve.

Figure 3:

Block View for the Trunk Plan BCD Blocks: Anatomical structures meeting criteria for strong recommendation

Legend: IO internal oblique; **PL** pleura; **PMa** pectoralis major; **PsMa** psoas major; **PMi** pectoralis minor; **QL** quadratus lumborum; **R** rib; **R4** 4th rib; **SA** serratus anterior; **SCTL** superior costotransverse ligament; **TP** transverse process.

ENDS