An International Classification of Abdominal Wall Planes (ICAP) to Describe Mesh Insertion for Ventral Hernia Repair: A Delphi Consensus of Expert Hernia Surgeons.

Abstract

Background

Nomenclature for mesh insertion during ventral hernia (VH) repair is inconsistent and confusing. Several terms, including ‘inlay’, ‘sublay’, and ‘underlay’, can refer to the same anatomical planes in the indexed literature. This frustrates comparisons of surgical practice and invalidates meta-analyses comparing surgical outcomes according to the plane of mesh insertion. Consequently, the aim of this study was to establish an International Classification of Abdominal wall Planes (ICAP).

Methods

A Delphi study, involving 20 internationally recognised abdominal wall surgeons, was conducted. Different terms describing anterior abdominal wall planes were identified via literature review and expert consensus. The initial list comprised 59 possible terms. Panellists completed a questionnaire that suggested a list of options for individual abdominal wall planes. Consensus on a term was pre-defined as occurring when ≥80% of panellists selected it. Terms scoring <20% were removed.

Results

Voting started August 2018 and was completed by January 2019. During Round 1, 43 (73%) terms were selected by <20% of panellists and 37 new terms were suggested, leaving 53 terms for Round 2. Four planes reached consensus in Round 2 with the terms “onlay”,

“inlay”, “pre-peritoneal” and “intra-peritoneal”. Thirty-five (66%) terms were selected by <20% of panellists and were removed. After Round 3, consensus was then achieved for “anterectus”, “interoblique”, “retrooblique” and “retromuscular”. Default consensus was achieved for the “retrorectus” and “transversalis fascial” planes.

Conclusion

ICAP has been developed by consensus of 20 internationally recognized surgeons. Its adoption should improve communication and comparison among surgeons and research studies.

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Introduction

Abdominal wall reconstruction (AWR) is an evolving sub-specialty with increasing academic interest. Ventral hernias (VHs) are becoming more prevalent[1] and their repair presents a significant surgical challenge[2]. Consequently, academic surgeons must produce robust research to guide and improve best practice. During data extraction for a recent systematic review[3], the frequent inconsistent use of nomenclature for abdominal wall planes was identified. Varied terminology was used to refer to single anatomical planes. For example, the retro-rectus plane was variously referred to as either the 'inlay'[4,5],'sublay'[6,7] or 'underlay'[8] plane; the pre-peritoneal plane was referred to as the 'inlay'[9], 'sublay'[10] or 'underlay'[11] plane. Such variability misleads and confuses the reader and also affects meta-analyses targeted to compare surgical outcomes for differing planes of mesh insertion (e.g. sublay vs onlay plane[12,13]).

To highlight these inconsistencies a review article was published[14], which attracted significant interest and responses from the International Hernia Collaboration[15] and the McGovern Medical Center at the University of Texas in Houston[16]. These groups recognised an urgent requirement for consistent classification of abdominal wall planes for VH surgery. A globally accepted system that clearly defines and describes planes would eliminate ambiguity from the indexed literature and facilitate surgical comparisons whether by narrative review or meta-analysis.

Therefore, the aim was to achieve consensus by enlisting internationally recognised academic abdominal wall reconstruction surgeons and employing Delphi methodology[17] to establish an International Classification of Abdominal wall Planes (ICAP).

Methods

The Delphi method[17] was used to establish expert consensus. The Delphi method is a consensus-based technique that provides a systematic framework to collect and aggregate informed opinion from a group of experts, via multiple subsequent iterations[18]. The process consisted of five phases; questionnaire development (phase 1), expert panel selection (phase 2), followed by three rounds of questionnaire distribution, data acquisition and analysis, and iteration (phases 3, 4 and 5). Controlled feedback from sequential rounds encourages panellists to reassess, deliberate and either confirm or alter their responses. Delphi has been used extensively for research purposes[19,20,21], but has not previously been used to define the abdominal wall planes.

Questionnaire Development

The lead researchers, SGP, SH, MKL, FM and ACJW, designed two anatomical diagrams depicting the muscle and fascia of the abdominal wall cranial and caudal to the arcuate line (figure 1). A series of diagrams were then developed to show all possible abdominal wall planes employed currently for VH repair (figure 2). The diagrams included planes both frequently and infrequently used for abdominal wall reconstruction, since surgical innovation may well utilise additional planes in the future. Using these diagrams, a PowerPoint presentation was created (Microsoft PowerPoint for Mac 2016, Version 16.0, Microsoft Corporation, Washington, USA) highlighting the individual abdominal wall planes on consecutive slides. Eleven abdominal planes were labelled alphabetically, A to K (figure 2). Each slide also indicated the possible range of terms used previously for each plane, from

which panellists were asked to identify their preferred term. To avoid bias, options were listed alphabetically. For Round 1 only, a free text space on each slide allowed panellists to add additional terms and to comment. There were 13 slides in total; 1 introductory slide explaining the questionnaire format, followed by 11 slides of individual planes, and a final slide for additional comments. Participants were encouraged to suggest additional anatomical terms, questionnaire alterations and anatomical diagram adjustments on this final slide. The final questionnaire can be seen via online supplementary resource 1.

Identification of possible terms was multifaceted. A combination of literature review, expert consensus, and private correspondence was used. Extensive review of the abdominal wall literature was completed by SGP. After title and abstract screening of 6485 citations, and full-text review of 174 articles[3], manuscripts with published abdominal wall classifications systems[22-27] were analysed and the terms used were identified. In 2017, a web-based survey was conducted using the International Hernia Collaboration (IHC) Facebook platform[15]. One hundred and eleven surgeons with expertise in hernia surgery and abdominal wall reconstruction responded, listing 31 possible terms for abdominal wall planes. Our final list totalled 41 different possible terms (Online supplementary resource 2), many of which could be used to describe more than one anatomical plane and therefore appeared multiple times in our questionnaire, ultimately giving a total of 59 options (Online supplementary resource 2).

Before distribution, the questionnaire was piloted on volunteers at the University College London Hospital. Recommendations regarding presentation and usability were adopted.

Expert Panel Selection

The panellists were selected based on a combination of academic record and geographical location, so as to obtain a widely representative sample. For example, criteria included prominent membership of the American Hernia Society (AHS), British Hernia Society (BHS), European Hernia Society (EHS), German Hernia Society (DHS), and the Asian and Pacific Hernia Society (APHS). A priori it was determined that 20 panellists would be sufficient as a representative group.

Although patient and public involvement (PPI) can enhance Delphi studies[28], it was decided not to pursue their involvement given the nature and technicalities of this topic.

Questionnaire distribution, Data acquisition and Analysis, and Iteration

Panellists provided written consent and were asked to maintain anonymity until voting was concluded so as to avoid undue pressures from dominant or dogmatic individuals. Anonymity also allows individuals to reconsider options and maintain independence. Panellists were also asked to consent to COPE criteria[29], thereby authenticating co-authorship. The study protocol was approved by each panellist. Panellists also received copies of relevant publications[14-16] that highlighted inconsistencies in nomenclature, giving panellists further insight and focus. All panellists were also asked to declare any conflicts of interest (COIs).

SGP and SH did not vote but facilitated the study. They distributed the questionnaires, facilitated data acquisition, and performed data analysis. Between rounds, they re-distributed the results and questionnaires. Distribution and data acquisition occurred via electronic mail. It was anticipated that three voting rounds would be necessary to achieve consensus[30]. If not, a teleconference was planned, i.e. A “modified” Delphi technique[31]. Consensus was pre-

defined as ≥80% of panellists selecting an individual term for an abdominal wall plane. If <20% of panellists choose a term, this term was eliminated from subsequent rounds. After each round, all the responses were counted and tabulated as frequencies and percentages. Round 1 responses were fed back to each panellist as a table totalling the responses given for each plane and as, for this round only, a word document with the additional suggested terms and feedback comments. After Rounds 2 and 3, responses were communicated as a table totalling the responses for each individual plane. An updated questionnaire for the subsequent round of voting was sent out to each panellist at the same time as the results.

Figure 1. Anatomical diagrams designed by the lead researchers showing the muscle and fascia of the anterior abdominal wall (cranial is above the arcuate line, caudal is below the arcuate line).

Results

All surgeons approached agreed to participate and consented. Six panellists represented the USA (MKL, GLA, CMD, MTH, BTH and KMFI), 6 represented mainland Europe (FM, UAD, LNJ, AM, SMC, and YR), 5 represented the UK (ACdeB, DLS, NJS, JT, and ACJW), and 3 represented the rest of the worldwide surgical community; 1 South African (AB), 1 South Korean (JPH) and 1 Australian (NI). All panellists completed all 3 rounds of voting. Voting started 24th August 2018 and was completed 24th January 2019. Online supplementary resource 3 details the voting results from each Delphi round.

Round 1

During Round 1, 43 of the original 59 (73%) terms proposed were selected by less than four panellists (<20%) and, as per protocol, were eliminated. In addition, panellists added 37 new terms to the questionnaire, which were carried forward to Round 2. One panellist designed a novel nomenclature system and voted for these new proposed terms. Eighteen (90%) panellists voted for the term ‘onlay’ for plane A, but consensus was not declared as a new term, ‘Medial 1 and Lateral 1’, was proposed, and carried forward to the next round. Panellists made a total of 50 free text comments. These were fed back to panellists along with Round 1 results (Online supplementary resource 4).

Round 2

Fifty-three terms were offered to the panellists for Round 2s questionnaire. Consensus was achieved for planes A; ‘onlay’, C; ‘inlay’, J; ‘peritoneal’ and K; ‘intraperitoneal’ (figure 2), each receiving 18 (90%), 16 (80%), 18 (90%), and 18 (90%) votes respectively. Thirty-five (66%) terms were selected by less than four panellists (<20%) and did not make it to Round 3.

Round 3

Analysis of Round 2 results, by SGP, suggested that panellists found it challenging to define and name planes G and I. As these planes were in continuum, with plane G being the lateral portion of plan I, the facilitators decided to remove plane G (figure 2) from the Round 3 questionnaire, following approval by MKL, FM, and ACJW. Consequently, fifteen terms remained for 10 planes. Consensus was achieved for planes B; 'anterectus', D; 'interoblique', E; 'retrooblique, and H; 'retromuscular'. For the 2 planes, F and I, only 1 possible term remained by default (i.e. all other terms were selected by 3 or less panellists (<20%) and were removed as per protocol). For these two planes, panellists were asked, 'Do you have any strong objections to this term being the consensus term despite it being selected by default?'. For plane F, all 20 (100%) panellists did not object to the term 'retrorectus', which was consequently chosen. For plane I, 3 (15%) panellists objected, 1 (5%) preferred the term 'retromuscular' and 2 abstained. However, 17 (85%) panellists did not object, thus confirming the term 'transversalis fascial'. Figure 2. shows the final results of the Delphi process and the chosen terms. Figure 3 is an anatomical image of the results showing the planes with their respective terms chosen via consensus. Table 1 gives an anatomical description of each plane.

Figure 2. The results of the Delphi study showing all 11 planes. Terms for 10 out of 11 planes reached consensus. Planes H and I are divided into cranial and caudal sections as the posterior sheath is not present below the arcuate line. The anatomical difference between H and I is in the cranial images; medial to the semilunar line Plane I is posterior to the posterior sheath and Plane H is anterior to the posterior sheath. Plane H exists only if a transversus abdominis release is performed.

Figure 3. A summary diagram showing all the abdominal wall planes when their respect names chosen via Delphi consensus.

Table 1: Anatomical descriptions of each plane and their respective names chosen via Delphi consensus.

Discussion

Using Delphi methodology, a panel of internationally recognized experts in abdominal wall reconstruction have agreed a standardised nomenclature system for the planes of the abdominal wall to be used for mesh placement during VH repair. Inconsistency in the indexed literature suggests that this International Classification system of Abdominal wall Planes (ICAP) is required[14]. The authors wish to see ICAP adopted by abdominal wall surgeons and the wider medical community. ICAP should facilitate comparison and eliminate ambiguous anatomical descriptions in both the clinical and research settings. Furthermore, adoption would also benefit others working with these anatomical planes, such as radiologists and anaesthetists. It is desirable that all clinicians "speak a common language". In the academic setting, variable nomenclature frustrates investigators studying surgical outcomes comparing mesh placement into different anatomical planes. This is amplified in meta-analyses, where ambiguous terms (eg. sublay, inlay, underlay) cause uncertainty regarding the exact plane of mesh insertion[12,13,32]. The academic community would benefit from this new unambiguous and transparent classification system so that anatomical planes are defined precisely.

Academics have been calling for 'a common language' to describe hernia morphology since the turn of the century: At an international herniologists meeting in Switzerland, Volker Schumpelick in 1998 called for a classification of incisional hernias, which would enable 'multi-centre trials' and 'comparison of the literature'[33]. Consequently, VH classification systems began to emerge, but none were adopted for clinical practice[22,34]. At the 29th congress of the European Hernia Society (EHS) 2007, Andrew Kingsnorth, the Society's President, stressed that a classification system of VH was important and the literature was

comparing ‘apples and oranges’[35]. This led to the development of the EHS classification system of primary and incisional hernias[35]. This classification system has gained some traction in the literature and has been shown to correlate with clinical outcomes[36]. The EHS grading system is, however, a pre-operative descriptor of hernia location, length, and width and omits intra-operative variables. Since level 1 evidence suggests that using mesh for VH repair reduces recurrence[37], an accurate anatomical description of the plane into which mesh is implanted is required. Indeed, the exact ‘mechanism of recurrence’ may depend on mesh location[38]. Once precise nomenclature is established, future grading systems describing the exact location of mesh insertion may have greater clinical utility.

Standardised nomenclature will also aid scrupulous monitoring and surveillance of outcomes related to mesh implanted into different planes. Mesh implanted in one plane may demonstrate a different risk/benefit profile than the same mesh implanted into a different plane. Awareness of the possible long-term complications should result in thoughtful and meticulous practice. The exact location for the mesh implant must be planned and described precisely. Our unambiguous ICAP nomenclature system facilitates this. With the plane of insertion described clearly in the operation note, a reconstructive surgeon is able to scrutinise their previous actions should a hernia recurrence or other mesh complication occur. Moreover, planning future surgery, either explantation and/or insertion of a new mesh is simplified if the precise location of an existing mesh is known.

During this Delphi study, three panellists, raised concerns regarding the term ‘bridging’ for ‘plane C’, stating that, ‘bridging is the opposite to primary fascial closure’, and that, ‘bridging is a term that should only be used in combination with the plane into which the mesh is inserted’. In response to these comments the facilitators compiled a definition for

bridging as follows: *'Bridging is not a specific anatomical plane, it is a reconstruction method that can be used in many planes, e.g. bridging onlay, bridging retro-rectus, bridging intra-peritoneal etc".* Panellists were asked to vote for or against this definition at the end of the study and they agreed unanimously, implying that 'bridging' in-and-of itself should not be used to describe an individual plane. Furthermore, the authors agree with the European Hernia Society when it describes the *'mesh bridging technique'* as when *'the anterior fascia of the hernia defect is not completely closed'* and the *'mesh augmentation technique'* as when *'the anterior fascia of the hernia defect is closed'*[24]. Abdominal wall surgeons must be explicit in their operation note as to whether the anterior fascia has or has not been completely closed as surgical outcomes are significantly worse after bridged repair[39].

Plane I, the transversalis fascial plane, caused some difficulties amongst panellists, stemming from the anatomy of the transversalis fascia, its landmarks, and its name. In both Mike Rosen's Abdominal Wall Reconstruction (AWR) Atlas[40] and in Gray's anatomical textbook[41], the transversalis fascia is labelled clearly. In Gray's, it is described as a, '*thin layer of connective tissue lying between the deep surface of the transversus abdominis and the extra-peritoneal fat*'[41]. All panellists agreed that this fascial layer can be visualized posterior to the transversus abdominis. However, a few were uncertain whether this layer existed medial to the semilunar line and, if so, whether it could be dissected off the posterior rectus sheath to allow mesh placement. Gray's[41] describes this fascia in detail. The description is complex and difficult to visualize. The fascia does cross the midline and is continuous with many other fascial structures such as the thoracolumbar fascial, iliac fascia and the diaphragmatic fascia. Indeed, all these fascial layers envelop the abdominal cavity in a continuous layer, which one panellist described as the 'endo-abdominal fascia', and is synonymous with the endo-pelvic fascia. Given that our expert panel had difficulty

understanding the anatomy of this plane, and that AWR surgeons are designing new reconstructive techniques that place implants into planes not utilised previously, a thorough understanding of the anatomy of the transversalis fascia is required. Further work is needed to develop a concise and accurate anatomical description of this plane.

ICAP does name planes that to date have not been used commonly. To our knowledge, the anterectus plane has only been used in anecdotal instances known to ACJW. The interoblique plane has reportedly been entered during variations of the peritoneal flap repair, a technique that has become popular in Europe after a case series was published in 2014 by the Royal Infirmary of Edinburgh[42]. Surprisingly, the retrooblique plane, (more traditionally known as the neurovascular plane), has been used for mesh insertion. Carbonell et al[43] incised the posterior lamella of the internal oblique aponeurosis to access this plane. Their series of 20 repairs reported a recurrence rate of 5% at 12 months and no neurological complications, ie no long-term pain, abdominal wall paralysis, or abdominal wall dysfunction or asymmetry. Despite these results, this plane has not been investigated further, probably because of theoretical risks of neurovascular compromise. However, it cannot be predicted which planes will or will not be used in future. As surgery evolves and new bioprosthetic materials emerge, new planes may become appealing. This ICAP system attempts to pre-empt such developments by being exhaustive regardless of current preferences.

Lastly, it should be mentioned that it is not uncommon for AWR surgeons to use more than one plane. For example, if the posterior rectus sheath is exposed bilaterally and then a unilateral transversus abdominis release (TAR) is performed, as Renard et al[44] describe for lumbar hernia repair, the TAR side will use the retromuscular plane with the retrorectus plane used contralaterally. De Beaux combines the retrorectus and interoblique planes to tackle

complex ventral hernias arising from lateral oblique or transverse incisions[42]. It follows that AWR surgeons must innovate, combining multiple planes where necessary in order to achieve the strongest repair.

This study arose from an acute awareness amongst abdominal wall reconstruction academics that an unambiguous international classification system is required urgently to avoid confusion and enhance research reporting. Inevitably, such classifications are not static and must be flexible and change as new knowledge is accumulated. Accordingly, future updates may be required. In the meantime, the ICAP classification is a precise description of the abdominal wall planes achieved by expert consensus via a Delphi process and abolishes ambiguous terms such as 'sublay', and 'underlay'. The authors wish to see ICAP endorsed by the various international hernia societies so that clinical and academic nomenclature is consistent worldwide.

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Conflict of interest

Windsor A.C.J. declares conflicts of interest not directly related to the submitted work; consultant advisor for TELA BIO; educational grants and speaker for: BARD, LifeCell and Cook. Boutall A. declares conflicts of interest not related to the submitted work; travel grants from Ethicon, Bard, and Medtronic; consultancy work for Medtronic. De Beaux A. declares conflicts of interest not directly related to the submitted work; speaker for BD Bard & Medtronic, trainer for Bard BD. Heniford B.T. declares conflicts of interest not directly related to the submitted work; consultancy work for WL Gore, Stryker Corporation, Allergan Plc. Jorgensen L.N. declares conflicts of interest not directly related to the submitted work; educational grants from Bard BD and Medtronic. Montgomery A. declares conflicts of interest not directly related to the submitted work; speaker for Bard BD. Morales-Conde S declares conflicts of interest not directly related to the submitted work; speaker for Bard BD, educational work for Medtronic, Ethicon, Storz Medical, Olympus, Stryker Corporation, WL Gore, consultancy work for Dipro Medical. Muysoms F declares conflicts of interest not directly related to the submitted work; consultancy work for Medtronic, Intuitive Surgical, CMR surgical, Dynamesh, educational grants from Medtronic and Dynamesh, speaker for Bard BD. Renard Y. declares conflicts of interest not directly related to the submitted work; educational grants from Bard BD, Hartmann. Sanders D.L. declares conflicts of interest not directly related to the submitted work; educational grant, speakers fee and fee for post market surveillance from Medtronic, speakers fee and consultant for Bard BD. Smart N.J. declares conflicts of interest not directly related to the submitted work; educational and speaker grants from WL Gore and Medtronic. Torkington J declares conflicts of interest not directly related to the submitted work; speaker and consultant for Medtronic. Parker S.G,

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Ethical approval

Ethical permission is not required by our institution for Delphi studies.

Human and animal participants

This article does not contain any studies with human participants performed by any of the authors.

Informed consent

This article does not include patients, and therefore informed consent was not applicable.

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