Canadian Trauma Training Needs Assessment and Development of a Trauma Laparotomy Operative Assessment Tool

by

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Abstract

Background: Canadian general surgery trainees are required to achieve competence in multiple domains of trauma care such as the operative and non-operative management of injuries, performance of the role of trauma team leader, trauma-specific knowledge, teamwork, and communication. A gap between clinical exposure and the required operative competencies in trauma education has been identified. Additionally, there are no procedure-specific competency-based operative assessment tools available for general surgery trauma procedures.

Objectives: This work aims to: (1) Conduct a national needs assessment for Canadian general surgery trauma training; and (2) develop a novel competency-based formative operative assessment tool for the trauma laparotomy procedure.

Methods: A national needs assessment was conducted through a survey of general surgery educators and trainees. The survey encompassed a wide range of components of the trauma training experience and included questions on clinical exposure, completion of formal trauma courses, physical and human resources available for education, perceived deficits in training, and support for curriculum initiatives. A modified Delphi study was then conducted with an international panel of trauma surgeons and educators to identify a set of items to be included in a novel trauma laparotomy operative assessment tool. Strict consensus criteria were applied throughout the three rounds of the study. Items were modified based on Delphi panel comments.

Results: Perceived deficiencies in trauma training were identified including operative management for many injury patterns, trauma epidemiology, evidence-based practice, and community advocacy. There was strong support for a wide array of curriculum initiatives to improve trauma education among both educators and trainees. Competency-based curriculum

objectives and assessment tools for both technical and non-technical skills were strongly supported by participants. The modified Delphi study was conducted over three rounds. Items were categorized into four sections within the tool: pre-operative, intra-operative, post-operative, and global rating. At the end of the Delphi study, 17 items were included in the operative assessment tool.

Conclusions: At this time, both educators and trainees perceive the existing Canadian trauma training curriculum to be insufficient to meet the educational needs of general surgery residents. Competency-based approaches to education and assessment were strongly supported by both educators and trainees in the national needs assessment. A competency-based formative operative assessment tool for the trauma laparotomy procedure has been developed for use in general surgery trauma training. Future work should focus on developing a national competency-based trauma training curriculum and evaluation of the assessment tool for utility, feasibility, and additional supporting validity evidence. Furthermore, the assessment tool development process and validity studies may be replicated to develop a full suite of assessment tools for trauma operations.

Preface

This thesis is an original work by Joanna Ryan. The research projects included in this thesis received research ethics approval from the University of Alberta Health Research Ethics Board. Project 1 Name "General Surgery Residency Trauma Training", No. HREB-Pro00089343, April 8, 2019. Project 2 Name "Trauma Curriculum and Operative Assessment Tool Development", No. HREB-Pro00109353, April 1, 2021. Project 3 Name "Trauma Curriculum", No. HREB-Pro00066303, April 9, 2018.

The work included in this thesis was part of collaborative efforts. The research design was done in collaboration with my supervisor Dr. Brett Mador for the work presented in Chapters 2 and 3 and Dr. Simon Turner for the work presented in Chapter 3. Dr. Patrick Murphy contributed to the analysis of the data collected in the needs assessment (Chapter 2) portion of the study. Dr. W. Robert Leeper and Dr. Bradley Moffat contributed to the development of the operative assessment tool presented in Chapter 3. All data analysis for the work presented in Chapter 3 was completed by Joanna Ryan. Data collection and manuscript composition were completed by Joanna Ryan.

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List of Abbreviations

ACGME – Accreditation Council for Graduate Medical Education

ATLS – Advanced Trauma Life Support

ASSET – Advanced Surgical Skills in Exposure for Trauma

ATOM – Advanced Trauma Operative Management

CBME – Competency-Based Medical Education

DSTC – Definitive Surgical Trauma Case

FAST – Focused Assessment with Sonography in Trauma

ICU – Intensive Care Unit

OSATS – Objective Structured Assessment of Technical Skills

O-SCORE – Ottawa Surgical Competency Operating Room Evaluation

RCPSC – Royal College of Physicians and Surgeons of Canada

RTTDC – Rural Trauma Team Development Course

STARTT – Simulated Trauma and Resuscitation Team Training

Chapter 1: Introduction

Context of the Problem

In the Canadian general surgery curriculum, the Royal College of Physicians and Surgeons of Canada (RCPSC) has defined many competencies specific to trauma. By the time of graduation, trainees are expected to be capable of providing high-quality care in both operative and non-operative injury management (Engels et al., 2018; RCPSC, 2019). Furthermore, other competencies such as teamwork, communication, leading trauma resuscitations, and various domains of trauma-specific knowledge are required (RCPSC, 2019). It is imperative that all general surgeons, including those not working at dedicated trauma centers, are prepared to deliver lifesaving trauma care when injured patients arrive to their hospital (Engels et al., 2018).

Engels and colleagues (2018) describe a large gap between the trauma exposure and training provided to Canadian general surgery residents and the expectations of competency in practice. This commentary also highlights the need for a revised trauma training curriculum to address this issue (Engels et al., 2018). Both the locoregional trauma systems and institutional curricular resources contribute to the quality of trauma education for general surgery residents (Mador et al., 2020). For most training programs, the modifiable factors to improve trauma education lie within their curriculum components. Taking this into consideration, this work aims to address the identified gap by conducting a national trauma education needs assessment and the development of a procedure-specific competency-based operative assessment tool for trauma laparotomy.

Background

Competency-Based Medical Education

Medical training is shifting to competency-based medical education (CBME) and assessment models. The RCPSC is currently in the process of transitioning all disciplines to the CBME system. Each specialty has identified a set of competencies required of all new graduates. A core concept of the CBME model is a shift from time-based promotion and certification to performance-based progression (Frank et al., 2010). This model also supports a learner-centered educational experience, where learning goals and experiences can be tailored to an individual trainee's needs (Frank et al., 2010). The use of frequent assessments with multiple instruments and observers is key to supporting learners in CBME and measuring the development of competence (Holmboe et al., 2010; Lockyer et al., 2017).

The RCPSC has defined an extensive set of competencies for trauma in general surgery training (RCPSC, 2019). Technical skills competencies include operations to address injuries in the neck, chest, abdomen, retroperitoneum, pelvis, and extremities. Surgeons are also expected to provide non-operative management of injuries in these domains when appropriate. Additionally, general surgery residents must achieve competence in a variety of non-technical trauma skills. One of these key competencies is the ability to function in the role of Trauma Team Leader, coordinating the initial assessment and management of severely injured patients presenting to the emergency department. Finally, surgeons are expected to be capable of participating in trauma prevention initiatives, patient counselling and advocacy (RCPSC, 2019). In the United States, trauma care and operations are also considered to be within the essential skillset of the general surgeon (Bell et al., 2009; Bulinski et al., 2003). Further information on the trauma competencies can be found in the RCPSC document of general surgery competencies (RCPSC, 2019).

Current Landscape of General Surgery Trauma Training

Decreasing resident exposure to operative trauma cases has been well documented in the surgical literature (Ball et al., 2015; Bell et al., 2009; Bittner et al., 2010; Bulinski et al., 2003; Drake et al., 2012; Strumwasser et al., 2017; Yan et al., 2016). Many factors and changes in trauma care have contributed to this decline. Solid organ abdominal injuries (such as spleen and liver injuries) are being increasingly managed non-operatively (Bittner et al., 2010; Hawkins et al., 1998; Jennings et al., 2001). Furthermore, improved availability and accuracy of both diagnostic and interventional radiology have been contributors to this shift (Engels et al., 2018; Lukan et al., 2001). In both Canada (Engels et al., 2020) and the United States (Strumwasser et al., 2017), studies have demonstrated limited trainee exposure to key trauma operations. These data suggest resident clinical experiences may not be sufficient to allow for the appropriate development of competency in trauma surgery (Engels et al., 2018). Unfortunately, very little information is available on the clinical exposure and educational opportunities afforded to general surgery residents in the non-operative domains of trauma education and training.

Conceptual Framework for Trauma Curriculum Design

In 2020, Mador and colleagues published a conceptual framework for curriculum design in Canadian postgraduate trauma training. This framework was developed through a thematic analysis of structured interviews with trauma surgeons from across Canada and general surgery trainees (Mador et al., 2020). Two major themes were identified, the institutional context and curricular components. Institutional context was further broken down into the components of institutional culture, available resources, the loco-regional trauma system, and local trauma volumes (Mador et al., 2020). Curricular components encompassed transferability of skills from other areas of general surgery training, trainee outcomes and expectations, and educational

strategies including teaching, educational activities, and assessment methods (Mador et al., 2020).

This conceptual framework was developed to specifically address the complex Canadian trauma training environment (Mador et al., 2020). Canada is extremely diverse in its geography and population demographics; and variation in institutional factors such as trauma volumes, injury patterns, and educational resources can impact resident education (Mador et al., 2020). These factors are accounted for in the institutional context arm of the framework. The framework also addresses the transferability of skills from other areas to trauma training. In the current landscape of limited trauma operative exposure, the transferability of skills from other areas of general surgery becomes increasingly important (Mador et al., 2020). By emphasizing these key principles, the conceptual framework provides a strong foundation on which to build educational interventions to address curriculum gaps.

Delphi Methodology and Use in Assessment Design

In the Delphi methodology, a panel of content experts develops a consensus on a topic through a series of iterative questionnaires (Junger et al., 2017). Recommendations for the ideal Delphi study panel size vary but have been reported to be between 6-20 (Humphrey-Murto et al., 2017a; Louridas et al., 2017; Waggoner et al., 2016). In a Delphi study, panelists are administered a questionnaire and asked to rate their agreement with each item (Junger et al., 2017). Agreement can be measured on a Likert or other ranking scale. Ratings and comments are then collated, and the questionnaire with accompanying score statistics are returned to participants (Humphrey-Murto, 2017a). The Delphi study is conducted in an iterative manner until termination criteria have been satisfied (Humphrey-Murto et al., 2017a). The Delphi study typically ends when either all items have achieved consensus or the maximum number of rounds

set at the start of the study has been reached (Diamond et al., 2014; Humphrey-Murto et al., 2017a). Anonymity of responses between panel members should be maintained to mitigate potential bias in responses from social pressure (Junger et al., 2017). Traditionally, the first round of the Delphi study is open-ended to generate ideas and questions (Louridas et al., 2017). Subsequent rounds are then more directed and closed-ended (Louridas et al., 2017). Modified versions of the Delphi process are commonly used (Humphrey-Murto et al., 2017b), such as when a group of experts generate an initial list of items and the first round with the full panel is closed-ended (Humphrey-Murto et al., 2017a). The Delphi method has been previously used in the development of content items for operative assessment tools (Miskovic et al., 2013; Peyre et al., 2009; Turner at al., 2019; Turner et al., 2020a; Turner et al., 2020b).

Theory of Operative Assessment

Operative assessment can be broken down into two overarching categories – formative and summative assessment. Formative assessment is said to be an "assessment for learning" (Schuwirth & van der Vleuten, 2011, p. 784). This indicates formative assessment is intended to augment learning and provide feedback to enhance performance (Norcini & Burch, 2007; Schuwirth & van der Vleuten, 2011). This type of evaluation has been noted to improve both learner motivation and achievement (Norcini & Burch, 2007). In contrast, summative assessment can be seen as an "assessment of learning" (Schuwirth & van der Vleuten, 2011, p. 784). These assessments are commonly found in high-stakes situations and are intended to render a pass or fail, competent or not competent judgement (Schuwirth & van der Vleuten, 2011).

Validity has been described by Schuwirth and van der Vleuten (2011) as the "extent to which the test actually measures what it purports to measure" (p. 786). Cook and Beckman (2006) build on this concept with the statement "Validity is not a property of the instrument, but

of the instrument's scores and their interpretations" (p. 166.e8). In order to be applied in either a formative or summative context, an assessment should be supported by an argument and evidence for validity (Cook et al., 2015). The type and degree of supporting evidence required depends on the nature of the tool and its intended use (Gasmalla & Tahir, 2021). Summative or high-stakes assessments should undergo more rigorous validity testing (Cook et al., 2015; Gasmalla & Tahir, 2021). Gasmalla and Tahir (2021) also highlight that validity evidence for an assessment tool is context specific and may not be transferable to its use in other contexts.

In previous models of validity, the concepts of content, criterion, and construct validity were widely used (Cook & Beckman, 2006; Gasmalla & Tahir, 2021). More recently, medical education has shifted to the use of Kane's framework for validity arguments (Cook et al., 2015) and Messick's unitary framework of validity (Gasmalla & Tahir, 2021; Ghaderi et al., 2015). In these frameworks, the word construct is also used, but takes on the meaning of "an intangible collection of abstract concepts and principles" (Cook & Beckman, 2006, p. 166.e8; quoting Messick). In order to build a validity argument, a clear definition of the intended construct, scope, and use of the test must be established (Cook et al., 2015). Kane's framework describes four categories of inferences that contribute to a validity argument: scoring, generalization, extrapolation, and decisions or implications (Lineberry, 2020). Scoring encompasses whether the true performance of the examinee was captured by the assessment scores (Lineberry, 2020). This can be influenced by the assessment methods chosen and specific characteristics of assessment items (Cook et al., 2015). Generalization refers to how well the included assessment items and scores reflect the full breadth of the construct (Cook et al, 2015) and are not affected by construct-irrelevant variance such as differences in raters or timing of assessment (Lineberry, 2020). Extrapolation deals with how well the test items and scores reflect "real-world

performance" (Cook et al., 2015, p. 568). Finally, decisions refers to how the scores are used and the consequences of the scores and the decisions they inform to learners, educators, and other potentially affected parties (Cook et al., 2015; Lineberry, 2020). Kane's framework encourages the prioritization of the most relevant pieces of validity evidence and the testing of the weakest or least plausible assumptions associated with a test (Cook et al., 2015). The validity argument should be grounded in the intended use of the test (Lineberry, 2020).

The unitary framework of validity was introduced by Messick and describes five domains of validity evidence that may be used in support of a validity argument (Lineberry, 2020). The first is test content, referring to how the test items were developed, by whom, and how well they represent the construct to be tested (Cook & Beckman, 2006). Next is response process, describing how raters were trained, their thought processes while conducting an assessment, and the familiarity of assessors and those assessed with the tool and its use (Cook & Beckman, 2006). Internal structure encompasses studies of the reliability, generalizability, and internal consistency of an assessment tool (Cook & Beckman, 2006). Evidence for relations to other variables may include the demonstration of expected convergent or divergent correlation of scores with those from other instruments (Cook & Beckman, 2006). It may also include correlation of scores to external indicators such as level of experience or clinical outcomes (Ghaderi et al., 2015). Finally, consequences refers to the effects of the test scores, the methods for setting cut scores, and an assessment for unintended ramifications of the test scores or their use (Cook & Beckman, 2006). In assessment development, it has been suggested that both Kane and Messick's frameworks be used to guide tool design and studies to assemble validity evidence and arguments (Cook et al., 2015; Cook & Beckman, 2006).

Within the discipline of general surgery, a limited number formative and summative procedure-specific operative assessment tools are available (Ryan et al., 2022). Additionally, there are many essential procedures missing from this library of tools. One such gap is for trauma operations in general, and more specifically for the trauma laparotomy. As trauma laparotomy is an essential but uncommonly performed procedure for Canadian trainees (Engels et al., 2020), it is imperative that educators have access to resources to maximize the educational potential for clinical exposures to this operation when they arise. This work intends to address this gap within the surgical education literature.

Summary

CBME is becoming the new standard for medical education in Canada. In general surgery training, the RCPSC has outlined the required trauma training competencies including both technical and non-technical skills (RCPSC, 2019). A conceptual framework for trauma education has identified the institutional context (culture, resources, local trauma systems, and case volumes) and curricular components (transferability of skills, trainee outcomes, and educational strategies) as core principles underlying the trauma education curriculum (Mador et al., 2020). Resident operative case volumes in trauma are low and have been declining over recent decades (Engels et al., 2018). Furthermore, there is limited data available on trainee exposure to other aspects of trauma training. Maximizing the educational utility of trauma operations when they present themselves is paramount for general surgery resident trauma training. Formative assessment has been noted to augment trainee learning (Norcini & Burch, 2007) and can be applied in this setting. In order to be useful in this context, assessment tools must be well designed and supported by a validity argument and evidence. Kane and Messick's validity frameworks may be used to guide development and testing of assessment tools (Cook et al.,

2015). Competency-based operative assessment tools to facilitate structured, high quality formative feedback in trauma surgery are not currently available within the trauma and surgical education literature.

Research Questions

1. What are the current perceived deficits in Canadian trauma training?
2. What curriculum components and resources are supported by educators and trainees to address perceived deficiencies in Canadian general surgery trauma training?
3. What items should be included in a formative intent, competency-based operative assessment tool for the trauma laparotomy procedure?

Objectives

1. Conduct a national needs assessment for Canadian general surgery trauma training.
2. Develop a novel competency-based formative operative assessment tool for the trauma laparotomy procedure.

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Chapter 2: General Surgery Trauma Education Needs Assessment

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Introduction

General surgery residents throughout the developed world have seen a marked decrease in exposure to operative trauma cases over recent decades (Ball et al., 2015; Bell et al., 2009; Bittner et al., 2010; Bulinski et al., 2003; Drake et al., 2012; Musonza et al., 2019; Strumwasser et al., 2017; Yan et al., 2016). Adoption of evidence-based non-operative strategies for management of major injuries, increased involvement of subspecialized surgical services in trauma care, and improved technologies in radiology and endovascular procedures have all contributed to decline in operative case volumes (Ball et al., 2015; Burkhardt et al., 2009; Engels et al., 2018; Jennings et al., 2001; Lukan et al., 2001; Oliver et al., 2017). Studies examining American general surgery resident case logs have identified deficiencies in the operative management of abdominal injuries, neck exploration, repair of pelvic or retroperitoneal injuries, repair of major vascular injuries, and repair of thoracic injuries (Bell et al., 2009; Strumwasser et al., 2017). Unfortunately, this decline in operative case volumes is not limited to trauma but is pervasive throughout general surgery training in basic and complex essential procedures alike (Drake et al., 2012; Kairys et al., 2008; Kelly & Senkowski, 2009; Malangoni et al., 2013; McCoy et al., 2013; Mullen et al., 2016). Furthermore, this issue is particularly apparent in other subspecialties of general surgery such as hepatobiliary and thoracic surgery (Park et al., 2019; Ragalie et al., 2016).

There is a striking inconsistency between trauma exposure in training and expectations for independent practice. Program directors and licencing bodies consistently consider trauma operations to be within the essential skill set of the graduating general surgeon (Bell et al., 2009; Bulinski et al., 2003; RCPSC, 2017; RCPSC, 2019). While a formal trauma fellowship can offset deficiencies in operative case volumes (Strumwasser et al., 2017), the majority of residents do not pursue trauma fellowships. All surgeons in both urban and rural settings must be prepared to deliver initial, high-quality management, including high-stakes operative management, for trauma patients prior to transfer to a dedicated trauma centre.

With the expectation for competency in trauma care upon graduation, it is essential to ensure adequate trauma training is in place. Educators and surgical leaders have called for curricular reform to improve trauma training for general surgery residents and address challenges in achieving case volumes within the evolving trauma landscape (Engels et al., 2018). This study aims to identify the trauma educational priorities of educators and trainees and to highlight key opportunities for improvement in trauma training within Canadian general surgery residency programs. This study received approval from our institutional Research Ethics Board (Pro00066303).

Methods

This study was designed as a mixed methods needs assessment for trauma specific training of general surgery residents. As trauma is a multifaceted field with varying trainee needs within different contexts, we chose to utilize a combination of qualitative and quantitative methodologies to best describe the way forward for Canadian trauma education. Therefore, an initial qualitative analysis was performed, using data collected from focus groups with general surgery junior and senior residents from a single site, as well as semi-structured interviews with

trauma experts/educators from across Canada. Thematic analysis using a constructivist paradigm was performed and has been described previously (Mador et al., 2020). A conceptual framework was developed to guide further study including questionnaire development for national distribution (Mador et al., 2020). Figure 1 of this publication was reproduced with permission from Mador and colleagues (2020). For this thesis it has been removed for copyright reasons. The original figure can be accessed at DOI: 10.36834/cmej.68621

Data Collection and Survey Design

Survey questions were developed based on the previously described exploratory analysis. The survey consisted of free-text, multiple choice, and Likert-scale questions. Both English and French versions of the survey were created to be inclusive to all training programs in Canada. All Canadian general surgery residents were electronically invited to participate in this study. For the purposes of this study, residents in years 1-2 are considered junior and residents in years 3-5 of training are considered senior. Although there may be some variation among programs, this is the general trend for junior/senior resident designation within Canada. General surgery educators and trauma surgeons across the country were also invited electronically to participate, with participants chosen using purposive sampling. Specifically, this included trauma surgeons with roles in education, as well as general surgery program directors and other general surgeons with official postgraduate educational roles. Email reminders were sent to improve survey response rates. Basic demographic information including gender and level of training (trainees) or years in practice (educators) was collected. Participants were asked about the trauma training experience at their institution, their attitudes on trauma training, educational initiatives in place at their program, and their opinions on an ideal trauma curriculum. In questions with the term "adequacy", the term is defined by the participants' perception of sufficient training. Agreement

or acceptance was considered when over 50% of respondents either "agreed" or "strongly agreed" with a statement or responded "yes". Deficiency or disagreement was determined to be less than 50% agreement. Participants were given the option to complete the survey in their preferred language and all responses were compiled and analyzed together. A copy of the survey is provided in Appendix A.

Data Analysis

Only complete surveys were used, 9 participants (2 educators and 7 trainees) with incomplete responses were excluded from data analysis. Descriptive statistics were calculated for each variable using frequencies and percentages. All descriptive analyses were performed using STATA 13.0 (College Station, TX).

Results

Demographics

Response rates were 45% (31/69) and 14% (58/405) for educators and trainees respectively. There was a larger proportion of female residents (62%) compared to female educators (26%). Educators at early and late stages of their careers were represented with length of practice ranging from 1-5 years to over 25 years. Trainees from all levels of training responded (Table 2.1).

Table 2.1. Participant demographics.

Educator (N=31)			**Trainee (N=58)**		
Years in Practice	Male n (%)	Female n (%)	**Training Level**	Male n (%)	Female n (%)
1-5	11 (48)	2 (25)	PGY1	2 (9)	7 (19)
6-10	3 (13)	1 (13)	PGY2	6 (27)	8 (22)
11-15	5 (22)	2 (25)	PGY3	8 (36)	9 (25)
16-20	2 (8)	2 (25)	PGY4	1 (5)	7 (19)
21-25	1 (4)	0 (0)	PGY5	3 (14)	4 (11)
25+	1 (4)	1 (13)	PGY5+	2 (79)	1 (3)

Attitudes on Trauma Training

A majority of both educators (87%) and trainees (98%) agreed trauma is an important aspect of general surgery training. However, only approximately half of each group felt their residency training program provided adequate trauma training to meet their needs as a general surgeon. Many faculty felt physical resources such as a simulation centre were satisfactory (77%), with only 55% of trainees in agreement. A majority of both groups reported while clinical trauma exposure may be sufficient for junior residents (educators 61%, trainees 67%), volumes for senior residents were inadequate (42%, 41%). Both groups agreed their institutions contain sufficient trauma expertise for learning (65%, 79%), trauma care provided to patients is adequate (71%, 81%), and there is a positive culture and learning environment around trauma (67%, 62%). Educators (61%) and trainees (81%) agreed procedural skills learning can be transferable from other areas of surgery. Trainees (74%) supported the same for non-procedural skills such as leading a cardiac arrest vs. trauma resuscitation. Educators (48%) felt these non-technical skills were trauma-specific and not transferable from other areas (Table 2.2).

Table 2.2. Educator and trainee attitudes toward trauma training at their currently affiliated residency training program.

	Educator n (%) (N=31)	**Trainee n (%) (N=58)**
Trauma is an important aspect of general surgery training	27 (87)	57 (98)
Trauma training at my residency training program is currently adequate to meet my educational needs as a general surgeon	18 (58)	34 (60)
Physical resources for trauma education at my residency training program are adequate (i.e. simulation centre)	24 (77)	32 (55)
On average, clinical trauma exposure (i.e. case volumes) are adequate at my residency training program for **junior residents**	19 (61)	39 (67)
On average, clinical trauma exposure (i.e. case volumes) are adequate at my residency training program for **senior residents**	13 (42)	24 (41)

There is currently enough trauma expertise at my residency training program	20 (65)	46 (79)
Trauma care provided for patients at my residency training program is adequate	22 (71)	47 (81)
Our institutional culture around trauma care helps create a positive learning environment	21 (67)	36 (62)
The learning of procedural skills for trauma is transferable from other areas (i.e. bowel resection for trauma vs. bowel resection for cancer)	19 (61)	47 (81)
The learning of non-procedural skills for trauma is transferable from other areas (i.e. leading a cardiac arrest resuscitation vs. leading a trauma resuscitation)	15 (48)	43 (74)

Injury Management Training – Operative and Non-Operative

Nearly all trainees reported successful completion of the Advanced Trauma Life Support (ATLS) course (95%). Completion of advanced trauma courses beyond ATLS was uncommon and all residents who completed such a course were senior residents (Table 2.3). Educators and trainees both identified adequate training in the non-operative management of thoracic injuries (educators 65%, trainees 78%), intraperitoneal abdominal injuries (84%, 97%), retroperitoneal and pelvic injuries (71%, 79%), traumatic brain injuries (65%, 59%), and major orthopedic injuries (54%, 55%) at their training program. Both groups reported adequate training in the operative management of intraperitoneal abdominal (71%, 83%) injuries, but conversely identified deficiencies in the operative management of thoracic injuries (13%, 28%), mediastinal injuries (3%, 14%), neck injuries (16%, 33%), and vascular injuries (26%, 47%). Additional deficiencies were noted in the non-operative management of mediastinal (45%, 52%) and neck injuries (48%, 65%). Trainees (60%) agreed their training in the operative management of retroperitoneal and pelvic injuries was adequate. Only 29% of educators supported this statement (Table 2.4).

Table 2.3. Resident completion of trauma courses.

Trauma Course	Senior Resident Course Completion n (%) (N=36)	Overall Resident Course Completion n (%) (N=58)
Advanced Trauma Life Support (ATLS) Provider	34 (94)	55 (95)
ATLS Instructor	12 (33)	13 (22)
Rural Trauma Team Development Course (RTTDC)	0 (0)	0 (0)
Advanced Trauma Operative Management (ATOM)	6 (17)	6 (10)
Definitive Surgical Trauma Care (DSTC)	2 (6)	2 (3)
Advanced Surgical Skills for Exposure in Trauma (ASSET)	2 (6)	2 (3)
Simulated Trauma and Resuscitation Team Training (STARTT)	4 (11)	4 (7)

Table 2.4. Educator and trainee perception of adequate training in domains of trauma training.

	Educator n (%) (N=31)	Trainee n (%) (N=58)
Non-operative management of thoracic injuries	20 (65)	45 (78)
Operative management of thoracic injuries	4 (13)	16 (28)
Non-operative management of mediastinal injuries	14 (45)	30 (52)
Operative management of mediastinal injuries	1 (3)	8 (14)
Non-operative management of neck injuries	15 (48)	37 (65)
Operative management of neck injuries	5 (16)	19 (33)
Non-operative management of intraperitoneal abdominal injuries	26 (84)	56 (97)
Operative management of intraperitoneal abdominal injuries	22 (71)	48 (83)
Non-operative management of retroperitoneal and pelvic injuries	22 (71)	46 (79)
Operative management of retroperitoneal and pelvic injuries	9 (29)	35 (60)
Management of vascular injuries	8 (26)	27 (47)
Management of traumatic brain injuries	20 (65)	34 (59)
Management of major orthopedic injuries	17 (54)	32 (55)
Management of stab wounds	19 (61)	48 (83)
Management of gunshot wounds	9 (29)	30 (52)
Airway management	9 (29)	33 (58)
General resuscitation of major trauma patients	24 (77)	52 (90)
Blood transfusion and coagulopathy in major trauma	22 (71)	47 (81)
Diagnostic testing in major trauma patients	26 (84)	55 (95)

Focused Assessment with Sonography in Trauma (FAST Ultrasound)	24 (77)	34 (59)
Inpatient management of major trauma patients on the ward	22 (71)	49 (85)
Inpatient management of major trauma patients in intensive care	22 (71)	45 (78)
Leadership and teamwork skills	21 (68)	50 (88)
Communication skills	22 (71)	52 (90)
Trauma systems	14 (45)	42 (72)
Trauma epidemiology	11 (35)	29 (50)
Trauma research, including best evidence and guidelines	14 (45)	33 (57)
Trauma quality improvement	12 (38)	28 (48)
Safety and injury prevention	8 (26)	30 (52)
Health advocacy for vulnerable trauma populations (i.e. minorities, elderly, homeless)	9 (29)	28 (48)

Non-Technical Skills Training

A high proportion of both trainees (86%) and educators (87%) reported their training programs provided residents with opportunities to lead real trauma resuscitations under supervision. Educators and trainees agreed training in the general resuscitation of major trauma patients (educators 77%, trainees 90%), blood transfusion and coagulopathy in trauma (71%, 81%), diagnostic imaging (84%, 95%), Focused Assessment with Sonography with Trauma (77%, 59%), inpatient (71%, 85%) and ICU (71%, 78%) management of trauma patients, leadership and teamwork skills (68%, 88%), and communication skills (71%, 90%) were adequate at their program. Deficiencies were identified in trauma systems (educators 45%) and epidemiology (35%, 50%), research (educators 45%), quality improvement (38%, 48%), safety and injury prevention (educators 26%), and health advocacy training (29%, 48%). Results are summarized in Table 2.4.

Attitudes on the Ideal Trauma Curriculum and Support for Educational Initiatives

A majority of both educators and trainees supported all proposed educational initiatives as elements of an ideal trauma curriculum. Educators and trainees indicated support for the use of competency-based assessment tools for procedural skills (educators 90%, trainees 72%) and use of these tools for non-procedural skills evaluation (84%, 66%). Initiatives with the highest degree of support (≥80% overall agreement) from all participants included a trauma journal club, weekly service rounds or lectures on rotating trauma topics, quality improvement rounds, interactive trauma case review sessions, opportunities to lead trauma resuscitations under supervision, trauma simulations focused on resuscitation, technical skills, teamwork and leadership, and operative exposure with live animals (Table 2.5).

Table 2.5. Educator and trainee support for ideal trauma training curriculum initiatives.

	Ideal Curriculum Initiative	
	Educator n (%) (N=31)	**Trainee n (%) (N=58)**
Participation in daily, interprofessional service rounds	25 (83)	34 (59)
Daily radiology review of trauma inpatients' new imaging	24 (77)	49 (85)
Weekly review of trauma guidelines (various topics)	23 (74)	52 (90)
Trauma journal club	26 (84)	47 (81)
Weekly service rounds/lectures/sessions on rotating trauma topics	28 (90)	51 (88)
Quality improvement (morbidity and mortality) rounds specific to trauma	30 (97)	50 (86)
Interactive trauma case review sessions (informal discussion of recent cases)	28 (93)	54 (93)
Opportunities to lead real trauma resuscitations under supervision	29 (94)	57 (98)
Trauma simulations focused on resuscitation	28 (90)	55 (95)
Trauma simulations focused on technical skills (chest tubes, cricothyrotomy, etc.)	30 (97)	52 (90)
Trauma simulations focused on teamwork and non-technical skills (leadership, situational awareness, etc.)	29 (94)	49 (85)

Trauma simulations focused on operative exposure/maneuvers (without cadavers or live animals)	24 (77)	48 (83)
Trauma simulations focused on operative exposure/maneuvers (with cadavers)	24 (77)	52 (90)
Trauma simulations focused on operative exposure/maneuvers (with live animals)	25 (81)	52 (90)
Community initiatives involving injury prevention and/or health advocacy	18 (58)	37 (64)
Direct involvement in trauma research	26 (84)	38 (66)
Competency-based goals and objectives for the curriculum	27 (87)	43 (74)
Competency-based assessment tools for procedural skills	28 (90)	42 (72)
Competency-based assessment tools for non-procedural skills	26 (84)	38 (66)

Discussion

The vast majority of participants (87% of educators and 98% of trainees) agreed trauma is an important aspect of general surgery training and that current training is lacking in certain domains. Specifically, participants reported deficiencies in training for the operative management of thoracic, vascular, and neck injuries. These results have important implications for the development of a trauma curriculum and experience that will allow graduating general surgery residents to manage operative and non-operative trauma.

The Royal College of Physicians and Surgeons of Canada goals and objectives and competencies for general surgery training expects graduates to have sufficient clinical knowledge and operative skill to independently manage neck, thoracic, intraabdominal, retroperitoneal, pelvic, and vascular injuries (RCPSC, 2017; RCPSC, 2019). Canada's diverse geography and population influences the trauma volumes at centres across the country, likely leading to varied resident exposure between training programs. In Alberta, operative trauma cases declined substantially from 1995 to 2011 with trauma laparotomy rates decreasing from

17% to 5% of major trauma patients (Ball et al., 2015). A recent study at a single Level 1 trauma centre has shown a low volume of trauma operations per resident with many residents never being exposed to a neck exploration or thoracic operation for trauma throughout the course of their residency training (Engels et al., 2020). Work is currently ongoing to quantify operative trauma case volumes for Canadian residents across the country. Limited exposure to operative trauma is not unique to Canadian training programs. On a global scale, similarly low resident case volumes for operative trauma have been documented in the United States (Bell et al., 2009; Drake et al., 2012; Strumwasser et al., 2017), Australia (Di Re et al., 2019) and Denmark (Kjaergaard et al., 2016).

Our study clearly demonstrates perceived inadequacy of training from the perspective of residents and educators. Completion of a trauma fellowship has been demonstrated to alleviate the deficiencies noted in operative case volumes (Strumwasser et al., 2017). However, the majority of trainees do not pursue additional trauma training post-graduation. At our institution, less than 10% of graduates have pursued additional trauma training. The national rate is expected to be similar. In American programs, 16% of general surgery residents who completed fellowship training undertook that training in trauma (Adra et al., 2012). It should be noted that the true number of graduates obtaining additional trauma training is likely lower when accounting for those who did not undertake any formal fellowship training. Therefore, additional training post-graduation cannot be relied upon to supplement trauma training for the average general surgery resident.

One potential solution to address inadequate trauma operative exposure is exposure to similar anatomic regions in elective or emergency general surgery. Consistent with our data, previous qualitative investigation has shown both educators and trainees believed procedural

skills were transferable to trauma from other areas of general surgery (Mador et al., 2020). This likely accounts for the increased support from both educators and trainees that training is adequate in the management of intra-abdominal injuries. With the changing trends in trauma management, general surgery residents have seen declining exposure to elective vascular, thoracic, and neck operations (Ball et al., 2015; Burkhardt et al., 2009; Engels et al., 2018; Jennings et al., 2001; Lukan et al., 2001; Oliver et al., 2017). If residents are not exposed to elective procedures in these areas, it becomes difficult to acquire the necessary skills outside the trauma setting (Mador et al., 2020). This issue may be mitigated by the implementation of longitudinal objective competency-based assessments throughout residency training for both procedural and non-technical skills (Harris et al., 2020). Such assessments would show progression to competency and allow for early identification of learners requiring additional training.

While clinical trauma exposure has declined; both residents and educators agreed the basic physical infrastructure and trauma expertise required to implement trauma educational initiatives were already present at their training facilities. With these resources in place, programs are well poised to augment their delivery of trauma education to their residents beyond clinical exposure alone. There was strong support (>80%) for the use of trauma journal club, interactive case reviews, quality improvement rounds, supervised leadership in real trauma resuscitations, and use of simulation focused on both procedural and non-procedural skills.

Residents typically split their training between many sites and may have limited exposure to trauma centres (Engels, et al., 2018). It is imperative that training programs ensure that residents have the opportunity to engage in all established educational activities either in person or through remote virtual attendance to accommodate learners at multiple teaching sites.

Interview and focus group data support frequent observations with feedback as a strategy to enhance trauma training (Mador et al., 2020). As general surgery training transitions to the competency-based education model, training programs have an opportunity to reform and standardize a national trauma curriculum. This study has highlighted key areas to target ranging from resuscitation to operative injury management to soft skills such as teamwork and communication. Trauma-specific knowledge and competencies such as trauma research and quality improvement, health advocacy and injury prevention, trauma systems and epidemiology were also identified as areas for improvement. The trauma curriculum must address each of these areas to produce well-rounded surgeons prepared to deliver trauma care independently to Canadians across a broad geographical area.

Our conceptual framework highlights the importance of the institutional context to trauma curricular development (Mador et al., 2020). While there is undoubtedly variability between institutions, this data does support the presence of adequate facilities and resources to support trauma training at Canadian training sites, along with well-managed trauma systems and a positive culture around trauma care. Combined with the general acceptance of transferability of technical skills, and support for new strategies for learning such as remote sessions and competency-based education, this data points the way forward for trauma training. In order to make up for low overall trauma case volumes nationwide, these strategies will need to be focused on the identified discrete deficit areas.

Our study has limitations. Firstly, the response rate from the trainees was low, introducing the potential for response bias. Multiple attempts were made to improve survey completion. Ultimately, this response rate is not uncommon for survey studies of this size. Secondly, the study relies on the perceptions of individuals, and lacks associated data regarding

trainee competence, training volume, and objective inventory of educational initiatives/resources at each site. While this is a common issue to most survey studies, in this case a complementary study is currently underway to address this gap and obtain more objective data on these topics. These limitations are balanced by the broad scope of educators and trainees from both English and French speaking programs, and the use of rigorous qualitative analysis of preliminary data to frame the quantitative questionnaire.

Conclusions

Trauma training in Canada is presently perceived to be insufficient to meet the needs of the graduating general surgery resident. Educators and trainees have identified opportunities for improvement in training and support educational initiatives targeting both procedural and non-procedural skills. The data collected in this study will help facilitate the development of a standardized trauma curriculum and educational innovations to optimize training.

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Chapter 3: Development of Trauma Laparotomy Operative Assessment Tool

Introduction

Assessment of operative competency is an integral part of a surgical education program. Practice guidelines for operative assessment recommend residents undergo frequent observations of their operative performance, ideally completed by multiple faculty members (Williams et al., 2016). Furthermore, it is recommended that these assessments include specific feedback to the trainee to help facilitate improvement in future performance (Williams et al., 2016). Formative assessment with constructive feedback has been noted to support trainee education (Norcini & Burch, 2007). Structured operative assessment tools for use in formative assessment can provide educators with a framework for not only evaluating a resident's performance, but also for providing structured and detailed narrative feedback in the operating room and video-based assessment settings (Bello et al., 2018; McQueen et al., 2019; Zhao et al., 2020).

An assessment tool should be supported by a validity argument and evidence in order to make meaningful interpretations of the scores it produces (Cook et al., 2015). Contemporary validity theory is based on Kane's validity argument framework (Cook et al., 2015). This model suggests validity studies should be targeted to test the most important and weakest assumptions of the assessment (Cook et al., 2015). The unitary framework of validity, originally described by Messick, describes five categories of validity evidence that may be used in support of the validity argument (Cook & Beckman, 2006). These include content, response process, internal structure, relations to other variables, and consequences (Cook & Beckman, 2006). These domains encompass how the tool was developed and tested, how the assessment is conducted, and how the scores the assessment produces are used and interpreted (Cook & Beckman, 2006). For the purpose of this work, reliability studies will be considered within internal structure. In addition to

validity, other factors must be considered in the design and use of operative assessment tools. The Accreditation Council for Graduate Medical Education (ACGME) has defined a set of standards for medical education assessments (Swing et al., 2009). Assessments must not only demonstrate evidence for validity and reliability, but ideally, they should be easy to use, require minimal additional resources and time, be easy to interpret, and improve trainee performance (Swing et al., 2009).

In general surgery, residents are expected to become proficient in a myriad of procedures from the various subspecialties of the discipline. One such area is trauma surgery, more specifically, trauma laparotomy. This procedure is internationally considered an essential operative competency for general surgery training (ACGME, 2019; Intercollegiate Surgical Curriculum Programme, 2021; RCPSC, 2019). However, there is no operative assessment tool available within the literature specific to this procedure. Furthermore, trainee case numbers for this procedure tend to be low (Engels et al., 2020; Strumwasser et al., 2017). Therefore, it is essential for training programs to maximize the educational potential of these clinical experiences. This study aims to develop a novel procedure-specific formative assessment tool for the trauma laparotomy procedure.

Methods

Definition of the Construct and Scope of the Tool

The psychometric construct to be assessed by the tool was defined as "the minimum standard of performance in a safe and effective generic trauma laparotomy for blunt or penetrating abdominal trauma". Although some operative steps are common to all trauma laparotomy procedures, there can be great variation in the maneuvers required to identify and manage injuries depending on the mechanism, injury pattern, and the patient's clinical status.

Therefore, the construct definition was intentionally designed to be applicable to all trauma laparotomies. Furthermore, the tool is intended to assess trainee performance within the operating room only. Trainee activities performed prior to the operating room (such as in the trauma bay) and after the operation (follow-up care) are not within the scope of this tool. Both Kane and Messick's validity frameworks were used to guide the process of tool design and development. A modified Delphi methodology was used to develop an international consensus on the content of the operative assessment tool.

Scoring Anchor Criteria

The scoring anchor criteria for this tool were adapted from those used in the Ottawa Surgical Competency Operating Room Evaluation (O-SCORE) initially described by Gofton and colleagues (Gofton et al., 2012). The O-SCORE rating criteria employ an entrustability or autonomy-based rating system ranging from "I had to do" to "I did not need to be there" (Gofton et al., 2012, p. 1407). The original O-SCORE criteria may be accessed at DOI: 10.1097/ACM.0b013e3182677805

(Gofton et al., 2012). Minor modifications to the criteria were made to improve applicability to the trauma laparotomy procedure. Specifically, the highest level of entrustability was modified to read "I did not need to be there, in theory" and added the description of this criterion to be that the trainee could have completed the procedure adequately with a non-trauma surgeon assistant. Additionally, a sixth option of "Not Applicable" was added. This additional option was necessary to accommodate the variability in the specific components of the trauma laparotomy operation. Not all items in the tool would necessarily apply to every trauma laparotomy depending on the injury pattern. For example, if no injuries are identified, the items addressing injury management would not apply in that case. The decision to adapt the O-SCORE anchor

criteria for this tool had 3 main influences. The first is the O-SCORE instrument (including its scoring anchor criteria) has been tested and studied previously and already has some supporting validity evidence in other contexts (Gofton et al., 2012; MacEwan et al., 2016). Secondly, the entrustability-based criteria relate well to the tool's overarching goal of formative assessment to assist trainees in developing operative competency and ultimately autonomy in this procedure. Finally, the O-SCORE anchor criteria are already in use by the Royal College of Physicians and Surgeons of Canada within the Entrustable Professional Activity assessments in the CBME curriculum (RCPSC, 2017). Using familiar rating criteria allows for consistency among assessments within the general surgery residency curriculum and contributes to ease of use for faculty evaluators.

Delphi Panel

A diverse panel of trauma surgeons and educators were invited to participate in the study. Purposive sampling was used to identify candidates for the Delphi panel. This sampling method was chosen to promote a diverse geographical representation within the panel. Additionally, it allowed for the targeted inclusion of individuals with past or present leadership roles in surgical education, trauma surgery, and general surgery. Delphi questionnaires were distributed to panel members electronically via email. Panelists did not meet in a group or have any study-related contact. Panel members remained anonymous from each other throughout the duration of the study to limit the potential for bias in responses.

Consensus Criteria

Strict consensus criteria to include or exclude an item from the tool were defined a priori. For an item to be accepted to be included in the tool, at least 75% of respondents had to agree with inclusion of the item (score of 4 or 5). Additionally, a mean score of 4.5/5 or greater with a

mode score of 5 were required. To reject an item from the tool, an average score of 3 or less was required. Items not meeting either inclusion or exclusion criteria were required to be re-evaluated by the panel in the subsequent round. Strict criteria for item inclusion were used to ensure only items with very strong support from the panel were included in the tool. Similar Delphi consensus criteria have been previously successfully employed in the development of three operative assessment tools in thoracic surgery (Turner et al., 2019; Turner et al., 2020a; Turner et al., 2020b).

Item Writing and Delphi Rounds

A maximum of 3 rounds was defined prior to initiating the study. A modified Delphi methodology was used in this study where an initial set of potential items for inclusion in the tool was used as the first round questionnaire. This modification to the traditional Delphi process was made to allow for a maximum of three rounds of the Delphi study. It was anticipated that there would be modifications to items required based on panel feedback and that it would likely take several rounds to achieve consensus for inclusion or exclusion on all items. A maximum of three rounds has been suggested in the literature to maintain high study participation rates (Humphrey-Murto et al., 2017a). The study team comprised of content and education experts conducted a review of general surgery and trauma textbooks and journal articles to generate an initial list of potential items for the tool. Additionally, existing operative performance rating scales were examined for global rating items. The O-SCORE (Goften et al., 2012) and Objective Structured Assessment of Technical Skill (OSATS) (Martin et al., 1997) were examined in detail. The OSATS global rating scale has been widely applied and studied in many different surgical specialties and procedures (Vaidya et al., 2020). Additionally, it has been cited as one of the most widely studied assessments of surgical technical skill (Szasz et al., 2015). The themes

of global rating items were similar between these two instruments. The global rating items included in the novel trauma laparotomy assessment tool were adapted from those used in the OSATS (Martin et al., 1997) and O-SCORE (Gofton et al., 2012) tools and underwent modifications during the Delphi process. Items were divided into four domains: pre-operative, intra-operative, post-operative, and overall performance. The initial list of items comprised the Delphi questionnaire for the first round of the study. Within the study instructions, the psychometric construct, scope of the tool, and rating anchor criteria were provided to panelists.

Panelists were asked to rate their agreement for inclusion of each item in the tool on a 5-point Likert scale (1 – Strongly Disagree; 5 – Strongly Agree). Panelists were given the opportunity to comment on each item in a free-text response to suggest modifications. At the end of each operative phase section and the overall questionnaire, panelists had the opportunity to suggest new items for consideration by the panel in subsequent rounds. Mean, mode, and percent agreement (score of 4 or 5) were calculated for each item. Items meeting inclusion criteria were transferred to the final copy of the tool. Item comments were examined for common themes. If multiple panelists made similar item modification comments, items were altered accordingly and repeated in the next round for re-evaluation. New item suggestions were also included in the subsequent round to be evaluated by the panel. Descriptive statistics for each item repeated from the previous round were provided to panelists in rounds 2 and 3. This iterative process was repeated for a total of 3 rounds.

Data Analysis

Descriptive statistics (mean, mode, and percentage agreement) were calculated for each item at the end of each round of the Delphi study. All analyses were performed using Microsoft Excel (Version 16.59).

Results

Delphi Panel and Response Rates

A total of 26 individuals were invited to participate in the Delphi study. In the first round, 20 participants responded (response rate 76.9%). These 20 participants were then invited to participate in round 2 (20 responses, 100%) and round 3 (18 responses, 90%). The Delphi panel consisted of a geographically diverse group of individuals from three countries (Canada (13), United States (6), and South Africa (1)) to ensure representation of multiple practice patterns. All panelists (20, 100%) reported experience supervising undergraduate and postgraduate surgical trainees, and 18 panelists (90%) reported supervising clinical fellows. Additionally, the panel consisted of surgeons with a range of practice experience from less than 5 years to over 25 years in practice. Panel members were experts in trauma surgery and surgical education. Additionally, many panelists currently or previously held leadership positions in surgical education (residency program director, trauma fellowship program director, national surgical education committees) as well as in general surgery and trauma professional societies (Canadian Association of General Surgeons, Trauma Association of Canada, American College of Surgeons Committee on Trauma). A chief surgical resident pursuing a career in trauma surgery was included on the panel to provide a trainee perspective.

Item Ratings

Item ratings (mean and mode) by round are described in Table 3.1. At the time of item acceptance, all items had achieved a score of 4 or 5 by at least 75% of respondents. No items met criteria for exclusion from the tool, however many items underwent modification prior to being accepted. Items not meeting criteria for transfer to the final tool in rounds 1 and 2 were revised based on panelist comments. Additionally, when multiple similar comments were made, items

that did meet inclusion criteria were modified and re-queried to the panel. If the modified items met criteria to include in subsequent rounds, they were accepted to the final tool. One new item (Trainee Self Reflection) was added in round 2 based on panelist suggestions from round 1. Between rounds 2 and 3, the global rating items adapted from the O-SCORE (Gofton et al., 2012) and OSATS (Martin et al., 1997) "Technical Performance" and "Efficiency and Flow" (Gofton et al., 2012, p. 1407) were combined into a revised item based on comments of redundancy.

After the first round, 4 items were transferred to the tool unmodified, 10 items were modified based on panel comments, 2 items were moved from the intra-operative phase to the global rating phase of the tool per panelist comments, and 1 item was repeated in the second round unmodified. After the second round, 10 items were transferred to the final tool, 2 items were combined, and 2 items were re-queried to the panel unmodified. At the end of the third and final round, all remaining items met criteria for inclusion. Item scores and actions for each round are described in detail in Table 3.1.

Operative Assessment Tool

A 17-item trauma laparotomy operative assessment tool was generated through an international panel of expert trauma surgeons and surgical educators. The tool contains items in four domains: pre-operative, intra-operative, post-operative, and overall performance. Items along with their descriptive criteria achieved consensus among the Delphi panel. Descriptive criteria for each item are detailed in Table 3.2.

Table 3.1 Delphi panel ratings of operative assessment tool items.

	Round 1 (n=20)			Round 2 (n=20)			Round 3 (n=18)		
Item	**Mean**	**Mode**	**Action**	**Mean**	**Mode**	**Action**	**Mean**	**Mode**	**Action**
Pre-Operative Phase									
Pre-Op Communication	4.75	5	Modify	4.85	5	Accept	N/A		
Patient Positioning and Draping	4.70	5	Modify	4.60	5	Accept	N/A		
Situational Awareness	4.40	5	Modify	4.50	5	Accept	N/A		
Intra-Operative Phase									
Access	4.65	5	Modify	4.85	5	Accept	N/A		
Initial Exposure	4.68	5	Modify	4.90	5	Accept	N/A		
Control of Hemorrhage	4.70	5	Accept	N/A			N/A		
Control of Contamination	4.55	5	Accept	N/A			N/A		
Exploration & Injury Management (1)	4.55	5	Accept	N/A			N/A		
Exploration & Injury Management (2)	4.74	5	Accept	N/A			N/A		
Damage Control vs. Definitive Repair	4.75	5	Modify	4.80	5	Accept	N/A		
Intra-Operative Communication	4.50	5	Modify	4.79	5	Accept	N/A		
Post-Operative Phase									
Post-Op Planning	4.7	5	Modify	4.80	5	Accept	N/A		
Overall Global Rating									
Technical Performance	4.0	4	Move	4.1	5	Combine	4.56	5	Accept
Efficiency and Flow	4.3	5	Move	4.3	4	Combine	N/A		
Overall Performance	4.47	5	Repeat	4.44	5	Repeat	4.65	5	Accept
Trainee Self-Reflection	N/A			4.35	5	Repeat	4.53	5	Accept
Narrative Feedback – Positive	4.32	5	Modify	4.6	5	Accept	N/A		
Narrative Feedback – Constructive	4.5	5	Modify	4.63	5	Accept	N/A		

Table 3.2 Description of novel trauma laparotomy operative assessment tool items.

Item	Description
Pre-Operative Phase	
Pre-Op Communication	Communicates effectively with the interdisciplinary team (OR nursing, anesthesia, transfusion medicine, etc) to provide handover of pre-op events, coordinate ongoing resuscitation, and prepare for the procedure.
Patient Positioning and Draping	Correctly positions and drapes the patient as appropriate for injury mechanism and planned procedure(s).
Situational Awareness	Takes an active role in preparing for the case, formulates a plan including potential pitfalls, and displays appreciation for the situational urgency.
Intra-Operative Phase	
Access	Obtains safe, rapid access to the abdomen with an appropriately sized incision.
Initial Exposure	Appropriately utilizes maneuvers and assistants to obtain adequate exposure (such as early evacuation of clot and bowel evisceration, use of retractors, and selection of appropriate exposure for mechanism).
Control of Hemorrhage	Efficient and appropriate use of hemostatic techniques with escalation until hemorrhage is controlled.
Control of Contamination	Efficient and appropriate control of contamination given the global context of the operation.
Exploration & Injury Management (1)	Appropriately prioritizes and sequences injury exposure and management in a patient with multiple injuries.
Exploration & Injury Management (2)	Selects and performs appropriate manoeuvres to expose (opening of lesser sac, medial visceral rotation, etc) and manage injuries (splenic resection, bowel repair, etc).
Damage Control vs. Definitive Repair	Early recognition of the patient's overall status with appropriate selection of a damage control vs. definitive management approach.
Intra-Operative Communication	Engages in effective ongoing communication with the team including discussion around evolving events, anticipated needs, and postoperative disposition.
Post-Operative Phase	
Post-Op Planning	Makes and communicates an appropriate post-op plan including destination, orders, investigations, potential for complications, and plans for future procedures.
Overall Global Rating	
Technical Performance	Rate this trainee's overall technical skills in the context of this case.
Overall Performance	Rate this trainee's overall operative performance.
Trainee Self-Reflection	STOP – Prompt the trainee to self-reflect and describe what went well and opportunities for improvement.
Narrative Feedback – Positive	Describe at least one thing the trainee has done well in each of operative technique and non-technical skills.
Narrative Feedback – Constructive	Describe at least one opportunity for improvement in each of operative technique and non-technical skills.

Discussion

A novel operative assessment tool for the trauma laparotomy procedure was developed containing items relating to the pre-operative, intra-operative, post-operative aspects of this procedure as well as items addressing overall performance. Similar Delphi methodologies have been widely used in the development of other operative assessment tools (Miskovic et al., 2013; Peyre et al., 2009; Turner et al., 2019; Turner et al., 2020a; Turner et al., 2020b). The use of a panel of content experts in both surgical education and trauma surgery, as well as the iterative nature of the methodology used together demonstrate strong content validity evidence in support of this novel tool (Ghaderi et al., 2015). Furthermore, the clear definition of the construct to be tested and the intended test population (general surgery residents) and test use (formative assessment) provide surgical educators with the appropriate context for its use.

Formative assessment is an important part of competency-based education (Holmboe et al., 2010). It has been demonstrated to improve trainee performance and stimulate learning (Norcini & Burch, 2007; Schuwirth & van der Vleuten, 2011). To be most effective, formative assessment must provide the learner with specific and actionable feedback (Lewis et al., 2019; Ramani & Krackov, 2012). This concept is embedded in multiple aspects of the design of this tool. Firstly, the tool is procedure-specific with subdivisions for the different phases of the operation. This provides a framework for delivering detailed feedback on the key components of this procedure. Additionally, global rating items were included to provide trainees with an overall snapshot of their performance. Feedback is best when it is an interactive and dynamic conversation between a learner and a preceptor (Lewis et al., 2019; Ramani & Krackov, 2012). This promotes active learning and engagement in the learning process (Holmboe et al., 2010). This principle is incorporated with a specific prompt for the faculty observer to pause and invite

the trainee to self-reflect on their performance. Finally, qualitative narrative feedback has been shown to be a valuable component of formative assessment (Zhao et al., 2020). The final two items require narrative feedback on both technical and non-technical skills, describing areas of achievement and opportunities for improvement.

It is no longer sufficient to evaluate a trainee's technical skills alone (Holmboe et al., 2010). In the era of CBME, it is essential to consider other aspects relating to competency (Holmboe et al., 2010). In a trauma laparotomy, the surgeon not only takes on the role of operator, but also team leader. This operation often occurs in a high-stakes, high-stress environment and may include management of critical events. Therefore, in a trauma laparotomy, the surgeon's ability to communicate and work with the team effectively are essential components of competency. This tool specifically addresses the CanMEDS (RCPSC, n.d.) communicator and collaborator competencies as they relate to this procedure with dedicated items in the tool. Additionally, the tool requires that non-technical skills be addressed in the narrative feedback portion.

Through the Delphi study, the assumption that the operative assessment tool contains all essential items required to safely and effectively perform a trauma laparotomy was tested. Items were queried to the panel for rating for inclusion or exclusion from the tool or modification as well as feedback solicited for the addition of new items. All items included in the tool achieved consensus from the expert panel. This process was employed to ensure all relevant essential components of the procedure were represented within the assessment tool. Although the tool has a strong argument for its content, other domains of validity do not. Additional evidence to support the validity of the tool and its scores will be required. A pilot testing study will be conducted to gather this evidence. Additionally, during pilot testing data will be collected on

features of tool utility outlined by the ACGME such as time to train raters, time to complete the assessment, and materials required to successfully complete the assessment (Swing, 2009).

As this tool relies on expert raters to produce scores, rater training procedures will need to be developed and implemented in the pilot study. A secure online method to collect scores has been identified as multiple raters will be recording scores for the pilot study. As there is risk for rater bias in scoring, reliability studies should be conducted. The planned pilot study includes an assessment of inter-rater reliability. The tool items will be further assessed with a measure of internal consistency and item factor analyses. Additionally, scores from the tool will be compared with those produced by the OSATS global rating scale for the same performance and trainee level of experience. If the expected convergent correlation is demonstrated, this piece of evidence will further support that the tool accurately assesses trainees' operative performance in this procedure. Finally, faculty and trainee participants in the pilot testing will be surveyed on their perceived educational utility and usability of the tool. Planned testing by source of validity evidence is described in Table 3.3.

Table 3.3 Completed and planned validity studies and evidence items.

Domain	Planned or Completed Evidence Items
Content	Expert item writers – *competed* Delphi study – *completed*
Response Process	Rater training program Pilot testing Data storage/security - *completed*
Internal Structure	Inter-rater reliability Internal consistency Item factor analyses - Item difficulty - Item discrimination
Relations to Other Variables	Correlation to OSATS scores Correlation to level of experience
Consequences	Faculty perceptions of utility Trainee perceptions of utility

It is essential for programs to have a toolkit of assessments for both formative and summative use (Swing et al., 2009). Within trauma surgery, there is a lack of competency-based operative assessment tools. A recent review of procedure-specific tools in general surgery did not identify a single tool intended for use in trauma surgery (Ryan et al., 2022). However, in a recent needs assessment for trauma training and education, the use of competency-based assessment tools was strongly supported by both educators and trainees alike (Ryan et al., 2021). Moreover, a Delphi study of Canadian general surgery resident leaders identified the lack of appropriate assessment instruments to be a significant barrier to the implementation of competency-based training in general surgery (Huynh et al., 2019). This work and the resulting tool are a first step towards the development of a comprehensive competency-based assessment curriculum to support trauma surgery education.

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Chapter 4: Summary and Conclusions

Summary

Trauma is an important facet of Canadian general surgery training. Many competencies in this domain are required of general surgery trainees ranging from knowledge to initial management and resuscitation, surgical skills, and follow-up care (RCPSC, 2019). It has been well documented in the literature that trainee case volumes in operative trauma are low and have been declining over recent years (Bell, 2009; Engels et al., 2020; Strumwasser et al., 2017). Little is known about resident experience with and exposure to other aspects of trauma training. Canadian leaders in trauma surgery and education have noted the current curriculum and clinical exposure may not be sufficient to support residents in achieving the required competencies (Engels et al, 2018). Curriculum restructuring to a competency-based model with corresponding assessment tools and plans are one strategy to address this issue.

The conceptual framework for trauma training in Canadian general surgery programs developed by Mador and colleagues (2020), identifies two overarching themes – the institutional culture and curricular components. In this context, curricular components encompasses transferable skills from other areas of general surgery, the required competencies to be achieved, and assessments (Mador et al., 2020). The present work aimed to further investigate the curricular components aspect of this framework. A national needs assessment was conducted sampling learner and educator populations from across Canada (Ryan et al., 2021). The study population contained a diverse geographical and practice representation. This needs assessment confirmed that trauma education is considered an important aspect of general surgery training by both educators and trainees. However, only approximately half of each group felt their affiliated residency program provided adequate training in this area. Procedural skills were felt to be

transferable from other areas of the discipline, however, non-procedural knowledge and skills were perceived as trauma-specific. Operative management of trauma was highlighted as a perceived deficiency in training. Finally, there was strong support from both educators and learners for many curricular initiatives such as guideline and literature reviews, functioning in the role of trauma team leader, simulations, and the use of competency-based assessments for both procedural and non-procedural skills (Ryan et al., 2021).

A lack of competency-based operative assessment tools for trauma surgery was identified as a deficiency in the trauma training curriculum in the national needs assessment (Ryan et al., 2021). This work aimed to fill this gap through the development of a novel operative assessment tool for the trauma laparotomy procedure. A modified Delphi procedure with an international panel of trauma surgeons and educators was employed to develop a 17-item tool. The tool is intended for formative assessment and was carefully designed to provide meaningful and actionable feedback to residents to support education. This tool contains items to assess technical performance as well as communication and collaboration which are integral components of this operation. Development of the test content is only the first step; the tool will require additional reliability testing and collection of validity evidence prior to implementation in the trauma training curriculum. Contemporary validity frameworks were used to guide the development and inform future plans for validity testing of this tool.

Conclusions

Trauma education is an important aspect of general surgery training with many associated competencies (RCPSC, 2019). A national needs assessment has highlighted opportunities for improvement in the trauma training curriculum to help support resident education and achievement of competencies in this domain (Ryan et al., 2021). One such opportunity is the

development of a robust library of competency-based assessment instruments for both technical and non-technical trauma skills. A procedure-specific intra-operative formative assessment tool for the trauma laparotomy procedure has been developed. This tool may serve as a template for the development of a full complement of assessment tools in trauma surgery. Future studies should investigate educational interventions to address the remaining curriculum gaps identified in the needs assessment. Finally, the operative assessment tool developed as a part of this work will require additional testing prior to implementation. Both are areas of active work for our research group.

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Appendix A – Needs Assessment Surveys – Educator & Trainee

Appendix A has been published in:

Ryan, J.F., Murphy, P.B., Mador, B. (2021). A needs assessment of Canadian general surgery postgraduate trauma training. *Injury*, 52(9), 2534-2542. https://doi.org/10.1016/j.injury.2021.06.009.

Educator Survey

Part 1: Demographics

What is your current age?
- <31 years
- 31-35
- 36-40
- 41-45
- 46-50
- 51-55
- 56-60
- 61-65
- >65

What is your sex?
- Male
- Female

What residency training program are you **currently affiliated with**?
- University of British Columbia
- University of Calgary
- University of Alberta
- University of Saskatchewan
- University of Manitoba
- Northern Ontario School of Medicine
- McMaster University
- University of Toronto
- Western University
- Queen's University
- University of Ottawa
- McGill University
- Université de Montréal
- Université Laval
- Université de Sherbrooke
- Dalhousie University
- Memorial University

- Not currently affiliated with a residency program
- Other: _____

What residency training program did you **graduate from**?

- University of British Columbia
- University of Calgary
- University of Alberta
- University of Saskatchewan
- University of Manitoba
- Northern Ontario School of Medicine
- McMaster University
- University of Toronto
- Western University
- Queen's University
- University of Ottawa
- McGill University
- Université de Montréal
- Université Laval
- Université de Sherbrooke
- Dalhousie University
- Memorial University
- Other: _____

How many years have you been in practice (not including time spent in fellowship training)?

- Currently in fellowship
- 1-5
- 6-10
- 11-15
- 16-20
- 21-25
- >25

Where did you complete medical school training?

- Canada
- USA
- Other:____

In which clinical setting do you primarily work (or intend to work after completion of fellowship training)?

- Academic Hospital & Designated Trauma Centre
- Academic Hospital Non-designated Trauma Centre
- Any Academic Hospital (Either unsure or no preference about Trauma Designation)
- Non-academic/Community Hospital
- Non-hospital based practice
- Other
- Undecided

Part 2: Prior Trauma Training

Please indicate your prior trauma training experience **as a resident**. Only include rotations where you spent a minimum of one week on service. Do not include rotations completed as a medical student or fellow. Check all that apply:

- o No formal trauma service experience
- o Dedicated trauma service
- o Combined emergency surgery/trauma service

Which trauma courses have you successfully completed? Check all that apply:
None

- o ATLS provider course
- o ATLS instructor course
- o RTTDC course
- o ATOM course
- o DSTC course ASSET course
- o STARTT course
- o Other (list all):_____

Which trauma courses are you involved with as an instructor/educator:

- o None
- o ATLS provider course
- o ATLS instructor course
- o RTTDC
- o ATOM course
- o DSTC course
- o ASSET course
- o STARTT course
- o Other (list all):_____

Part 3: Attitudes Regarding Trauma Training

On a scale of 1 (strongly disagree) to 5 (strongly agree), how much do you agree with the following statements (in reference to your **currently affiliated residency program**):

	1 Strongly Disagree	2 Disagree	3 Neutral	4 Agree	5 Strongly Agree	N/A or Unsure
Trauma is an important aspect of general surgery training						
Trauma training at my residency training program is currently adequate to meet my educational needs as a general surgeon						
Physical resources for trauma education at my residency training program are adequate (i.e. simulation centre)						
On average, clinical trauma exposure (i.e. case volumes) are adequate at my residency training program for **junior residents**						
On average, clinical trauma exposure (i.e. case volumes) are adequate at my residency training program for **senior residents**						
There is currently enough trauma expertise at my residency training program						
Trauma care provided for patients at my residency training program is adequate						
A dedicated trauma service would improve trauma education for residents (select n/a if a dedicated trauma service, exclusive of combined emergency surgery/trauma services, already exists at your training program)						
Our loco-regional trauma system functions well						

Our institutional culture around trauma care helps create a positive learning environment						
The learning of procedural skills for trauma is transferable from other areas (i.e. bowel resection for trauma vs. bowel resection for cancer)						
The learning of non-procedural skills for trauma is transferable from other areas (i.e. leading a cardiac arrest resuscitation vs. leading a trauma resuscitation)						

Our general surgery residents learn the most when the leader (i.e. trauma team leader) of a trauma resuscitation has the following background (select one):

- General surgeon without trauma fellowship training
- General surgeon with trauma fellowship training
- Emergency physician
- Anesthesiologist
- Orthopedic surgeon
- Unsure
- Ideally a mixture of different specialties at different times

Part 4: Perceived Deficits in Trauma Training

On a scale of 1 (strongly disagree) to 5 (strongly agree), how much do you agree with the following:
General surgery residents at my currently affiliated residency training program (at the time of graduation) **receive enough training in**:

	1 Strongly Disagree	2 Disagree	3 Neutral	4 Agree	5 Strongly Agree	N/A or Unsure
Non-operative management of thoracic injuries						
Operative management of thoracic injuries						
Non-operative management of mediastinal injuries						
Operative management of mediastinal injuries						
Non-operative management of neck injuries						

Operative management of neck injuries						
Non-operative management of intraperitoneal abdominal injuries						
Operative management of intraperitoneal abdominal injuries						
Non-operative management of retroperitoneal and pelvic injuries						
Operative management of retroperitoneal and pelvic injuries						
Management of vascular injuries						
Management of traumatic brain injuries						
Management of major orthopedic injuries						
Management of stab wounds						
Management of gunshot wounds						
Airway management						
General resuscitation of major trauma patients						
Blood transfusion and coagulopathy in major trauma						
Diagnostic testing in major trauma patients						
Focused Assessment with Sonography in Trauma (FAST Ultrasound)						
Inpatient management of major trauma patients on the ward						
Inpatient management of major trauma patients in intensive care						
Leadership and teamwork skills						
Communication skills						
Trauma systems						
Trauma epidemiology						
Trauma research, including best evidence and guidelines						
Trauma quality improvement						
Safety and injury prevention						
Health advocacy for vulnerable trauma populations (i.e. minorities, elderly, homeless)						

Part 5: Existing Curricular Initiatives

The following trauma **initiatives are currently in place** at my currently affiliated residency training program:

	Yes	No	Unsure	Planned for near future
Participation in daily, interprofessional service rounds				
Daily radiology review of trauma inpatients' new imaging				
Weekly review of trauma guidelines (various topics)				
Trauma journal club				
Weekly service rounds/lectures/sessions on rotating trauma topics				
Quality improvement (morbidity and mortality) rounds specific to trauma				
Interactive trauma case review sessions (informal discussion of recent cases)				
Opportunities to lead real trauma resuscitations under supervision				
Trauma simulations focused on resuscitation				
Trauma simulations focused on technical skills (chest tubes, cricothyrotomy, etc.)				
Trauma simulations focused on teamwork and non-technical skills (leadership, situational awareness, etc.)				
Trauma simulations focused on operative exposure/maneuvers (without cadavers or live animals)				
Trauma simulations focused on operative exposure/maneuvers (with cadavers)				
Trauma simulations focused on operative exposure/maneuvers (with live animals)				
Community initiatives involving injury prevention and/or health advocacy				
Direct involvement in trauma research				
Competency-based goals and objectives for the curriculum				
Competency-based assessment tools for procedural skills				
Competency-based assessment tools for non-procedural skills				

Part 6: Ideal Curricular Initiatives

On a scale of 1 (strongly disagree) to 5 (strongly agree), how much do you agree with the following:

From an education standpoint, **I support the following instructional initiatives** in trauma care:

	1 Strongly Disagree	2 Disagree	3 Neutral	4 Agree	5 Strongly Agree	NA or Unsure
Participation in daily, interprofessional service rounds						
Daily radiology review of trauma inpatients' new imaging						
Weekly review of trauma guidelines (various topics)						
Trauma journal club						
Weekly service rounds/lectures/sessions on rotating trauma topics						
Quality improvement (morbidity and mortality) rounds specific to trauma						
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Trauma simulations focused on operative exposure/maneuvers (with cadavers)						
Trauma simulations focused on operative exposure/maneuvers (with live animals)						
Community initiatives involving injury prevention and/or health advocacy						
Direct involvement in trauma research						

Competency-based goals and objectives for the curriculum						
Competency-based assessment tools for procedural skills						
Competency-based assessment tools for non-procedural skills						

Part 7: Final Comments

List any additional ideas you have for a new/revised trauma curriculum:

Trainee Survey

Part 1: Demographics

What is your current age?
- <31 years
- 31-35
- 36-40
- >40

What is your sex?
- Male
- Female

What residency training program are you **currently enrolled in**?
- University of British Columbia
- University of Calgary
- University of Alberta
- University of Saskatchewan
- University of Manitoba
- Northern Ontario School of Medicine
- McMaster University
- University of Toronto
- Western University
- Queen's University
- University of Ottawa
- McGill University
- Université de Montréal
- Université Laval
- Université de Sherbrooke
- Dalhousie University
- Memorial University
- Not currently affiliated with a residency program
- Other: _____

What stage of training are you in?
- PGY1
- PGY2
- PGY3
- PGY4
- PGY5
- PGY>5 (excluding fellowship training)
- Fellowship

Where did you complete medical school training?

- Canada
- USA
- Other:____

In which clinical setting do you primarily work (or intend to work after completion of fellowship training)?

- Academic Hospital & Designated Trauma Centre
- Academic Hospital Non-designated Trauma Centre
- Any Academic Hospital (Either unsure or no preference about Trauma Designation)
- Non-academic/Community Hospital
- Non-hospital based practice
- Other
- Undecided

Part 2: Prior Trauma Training

Did you complete a rotation (at least one week) on a dedicated trauma service as a medical student?

- Yes, on site
- Yes, multiple sites
- No

Please indicate your prior trauma training experience **as a resident**. Only include rotations where you spent a minimum of one week on service. Do not include rotations completed as a medical student or fellow. Check all that apply:

- No formal trauma service experience
- Dedicated trauma service
- Combined emergency surgery/trauma service

Which trauma courses have you successfully completed? Check all that apply:
None

- None
- ATLS provider course
- ATLS instructor course
- RTTDC course
- ATOM course
- DSTC course ASSET course
- STARTT course
- Other (list all):_____

Part 3: Attitudes Regarding Trauma Training

On a scale of 1 (strongly disagree) to 5 (strongly agree), how much do you agree with the following statements (in reference to your **currently affiliated residency program**):

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There is currently enough trauma expertise at my residency training program						
Trauma care provided for patients at my residency training program is adequate						
A dedicated trauma service would improve trauma education for residents (select n/a if a dedicated trauma service, exclusive of combined emergency surgery/trauma services, already exists at your training program)						
Our loco-regional trauma system functions well						

Our institutional culture around trauma care helps create a positive learning environment						
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I learn the most when the leader (i.e. trauma team leader) of a trauma resuscitation has the following background:

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- Emergency physician
- Anesthesiologist
- Orthopedic surgeon
- Unsure
- Ideally a mixture of different specialties at different times

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Operative management of mediastinal injuries						
Non-operative management of neck injuries						
Operative management of neck injuries						

Non-operative management of intraperitoneal abdominal injuries						
Operative management of intraperitoneal abdominal injuries						
Non-operative management of retroperitoneal and pelvic injuries						
Operative management of retroperitoneal and pelvic injuries						
Management of vascular injuries						
Management of traumatic brain injuries						
Management of major orthopedic injuries						
Management of stab wounds						
Management of gunshot wounds						
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General resuscitation of major trauma patients						
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Communication skills						
Trauma systems						
Trauma epidemiology						
Trauma research, including best evidence and guidelines						
Trauma quality improvement						
Safety and injury prevention						
Health advocacy for vulnerable trauma populations (i.e. minorities, elderly, homeless)						

Part 5: Existing Curricular Initiatives

The following trauma **initiatives are currently in place** at my residency training program:

	Yes	No	Unsure	Planned for near future
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Direct involvement in trauma research				
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Competency-based assessment tools for procedural skills				
Competency-based assessment tools for non-procedural skills				

Part 6: Ideal Curricular Initiatives

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Trauma simulations focused on operative exposure/maneuvers (with live animals)						

Community initiatives involving injury prevention and/or health advocacy						
Direct involvement in trauma research						
Competency-based goals and objectives for the curriculum						
Competency-based assessment tools for procedural skills						
Competency-based assessment tools for non-procedural skills						

Part 7: Final Comments

List any additional ideas you have for a new/revised trauma curriculum: