



Quantifying the clinical exposure required to adequately prepare surgeons for deployment to conflict zones and to manage mass casualty situations.

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Dedication

This thesis is dedicated to my parents, Hayashi and Yumiko Uchino, who have given me their unwavering support to complete this work.

Declaration

I, **Hayaki Uchino**, declare that:

- (i) The research reported in this dissertation, except where otherwise indicated, is my original work.
- (ii) This dissertation has not been submitted for any degree or examination at any other university.
- (iii) This dissertation does not contain other persons' data, pictures, graphs or other information, unless specifically acknowledged as being sourced from other persons.
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Date: 04/10/2018

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Dr Victor Kong, my greatest mentor, for his patience, support and guidance throughout the project.

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Mr. and Mrs. Uchino, my wonderful parents, who sacrificed and provided so much for me, and never stopped supporting me.

Mrs. Kaori Uchino, my wife, for being my unrelenting cheerleader throughout my studies.

Lastly, to other colleagues and friends who have been so incredibly supportive. Thank you to all of you.

Abstract

Introduction: The ongoing state of global geo-political instability means that it is prudent, even in peaceful countries, to prepare civilian surgeons to manage major military-type trauma. However, preparing a modern surgeon to manage mass shooting or terrorist-related injuries remains an ongoing challenge in many countries. In addition, there is no consensus on the key skill set a modern trauma or military surgeon requires to competently manage major trauma patients.

Chapter 1 of this thesis reviews the trauma workload and operative exposure in a major South African trauma center and provides a comparison with contemporary experience from major military conflicts. It would appear that a South African trauma center has a sufficient burden of trauma and academic capability to train both military and civilian trauma surgeons. Based on our trauma workload, a 6-month rotation through a major South African trauma center should be sufficient to provide exposure to almost all major injuries in appropriate volumes to prepare a military surgeon for combat deployment.

Chapter 2 of this thesis reviews the state of trauma training and preparedness in Japan and the trauma workload of a major Japanese emergency medical center, and goes on to compare it with that of a major South African trauma center. The intention is to quantify and compare the time required to gain adequate exposure to major trauma at the two respective centers. It is apparent that trauma training in Japan is hampered by a lack of clinical material as well as by systematic factors. South Africa, in contrast, has a huge burden of trauma, sufficient academic infrastructure, and relatively modern facilities, which ensures that surgeons have adequate exposure to major trauma. Developing an academic exchange program between Japan and South Africa may allow for the transfer of trauma experience and skills between the two countries.

Chapter 3 of this thesis is a structured survey designed to investigate the role of international trauma clinical electives in South Africa, and to assess the impact these have had on the career of the various foreign surgeons who have undertaken them. The data demonstrated that an

international trauma clinical elective in South Africa provides unparalleled exposure to almost all forms of trauma in conjunction with a well-developed academic support program. The trainees who completed such an elective all felt that the trauma training with clinical exposure was of inestimable value and substantially enhanced their career.

Conclusion: South Africa has a sufficient burden of trauma to train surgeons to manage military and major civilian trauma. In addition, South African major trauma centers have sufficient academic support and capacity to ensure such training is structured and academically sound. In contrast, trauma training in Japan is impeded by a lack of clinical material as well as by systematic factors. Training a trauma-competent military or civilian surgeon in such an environment is difficult. An international trauma clinical elective in South Africa provides an unparalleled exposure to almost all forms of trauma in conjunction with a well-developed academic support program. For peaceful countries such as Japan, developing academic exchange programs with countries such as South Africa, which can offer broader trauma experience, is essential and can be mutually beneficial.

List of Abbreviations

BREC	Biomedical Research Ethics Committee
IRB	Institutional Review Board
PMTS	Pietermaritzburg Metropolitan Trauma Service
IALCH	Inkosi Albert Luthuli Central Hospital
KCH	Kurashiki Central Hospital
HIC	High-income country
DSTC	Definitive Surgical Trauma Care
PMB	Pietermaritzburg
MMC	Morbidity and Mortality Conference
KZN	KwaZulu-Natal
UKZN	University of KwaZulu-Natal
RTTD	Rural Trauma Team Development
ATLS	Advanced Trauma Life Support
SWs	Stab wounds
GSWs	Gunshot wounds
RTAs	Road traffic accident
ACS	American College of Surgeons
TCCC	Tactical Combat Casualty Care
JTS	Joint Trauma System

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Study development and rationale

I originally completed an international clinical elective in trauma surgery from 2011 to 2012, in Durban and Pietermaritzburg, and I re-applied for a similar international clinical elective in 2015. The reason I re-applied was the high quality of the trauma training I received in South Africa. My subjective impression was that it would be very difficult to obtain a similar depth of clinical exposure and supervised training in any other training system in the world. South Africa has a huge burden of penetrating and blunt trauma and this, combined with the availability of modern surgical resources, underpinned by a strong academic training program, means that South African trauma training is of a very high standard. The idea of this project began in 2015 during my second trauma elective. I have been interested in trauma in the aftermath of September 11, 2001. I was in the United States at the time and was struck by the fact that modern conflict was not restricted to front lines and remote war zones, but could strike at any moment in relatively peaceful civilian areas. Since then, the world has been in an ongoing state of global geo-political instability. Mass global migration, combined with ongoing financial insecurity, regional conflict, and religious radicalization, means that trauma will be a common occurrence for both military and civilian surgeons for the immediate future.

Several major military conflicts across the world are ongoing, and the scourge of urban terrorism is increasingly raising its head in a number of major cities that have known relative peace for a long time. Even Japan currently faces a number of existential threats, in the form of potential regional conflicts and urban terrorism. Civilian surgical services need to be prepared to manage large volumes of major trauma victims, and surgeons are expected to be competent to manage these severely injured patients. However, modern surgical training in High-Income Countries (HIC) is increasingly specialized. The ability of modern surgical teaching programs to train a surgeon who is competent and at ease treating injuries to multiple body regions with incomplete imaging and information is doubtful. In addition, the erratic pattern of trauma in HICs means that it is difficult to ensure that trainees have adequate exposure to the management of complex trauma patients. This means that modern surgeons trained in the HICs may well be uncomfortable

managing acutely injured patient with multiple competing injuries. This is especially the case for penetrating trauma and destructive blast injuries, as both of these injury patterns are uncommon in western Europe and Asia. In response to this, a number of solutions have been proposed, including the use of didactic courses such as the Definitive Surgical Trauma Care (DSTC) course. This course combines lectures, case solving, and the use of animal models and has been widely propagated. It is held in high regard, and it provides a solid theoretical framework for trauma care. The use of models and mannequins as well as live animals is expensive and, despite all the technological developments we now take for granted, these simulations retain an air of artificiality.

The need for practical experience in real-life trauma care remains essential for the development of the necessary skill set of both military and civilian trauma surgeons. Professor William Schwab eloquently alluded to this when he delivered the first US Army Major John P. Pryor Lecture at the American College of Surgeons meeting in San Francisco. His message was that military surgical training has to be coordinated between the armed services and civilian trauma centers. The problem remains that even in North America, few trauma centers manage the volume of trauma necessary to train military surgeons. On the other hand, the burden of trauma in South Africa means that unlike the situation in the developed world, trainees are constantly exposed to a significant volume of major trauma cases throughout their training rotations. Allowing international surgeons a chance to be exposed to trauma training in South Africa may be a useful way of developing trauma capacity globally. Surgeons who undertake such a rotation will be expected to return to their countries of origin and take a leadership role in developing trauma capability in their own countries. This project explores some of these critical issues in more detail and attempts to provide suggestions on how these clinical trauma electives can be developed and formalized to benefit both South Africa and the broader international community.

Study aims

The aims of this research project were:

1. To review the trauma workload and operative exposure in a major South African trauma center and provide a comparison with contemporary experience from major military conflicts.
2. To review the trauma workload of a major Japanese emergency medical center and compare it with that of a major South African trauma center. The intention of this project is to quantify and compare the time needed to gain adequate exposure to major trauma at the two centers.
3. To investigate and document the extent of international trauma clinical electives and to assess the impact these have had on the career of the various foreign surgeons who undertook them.

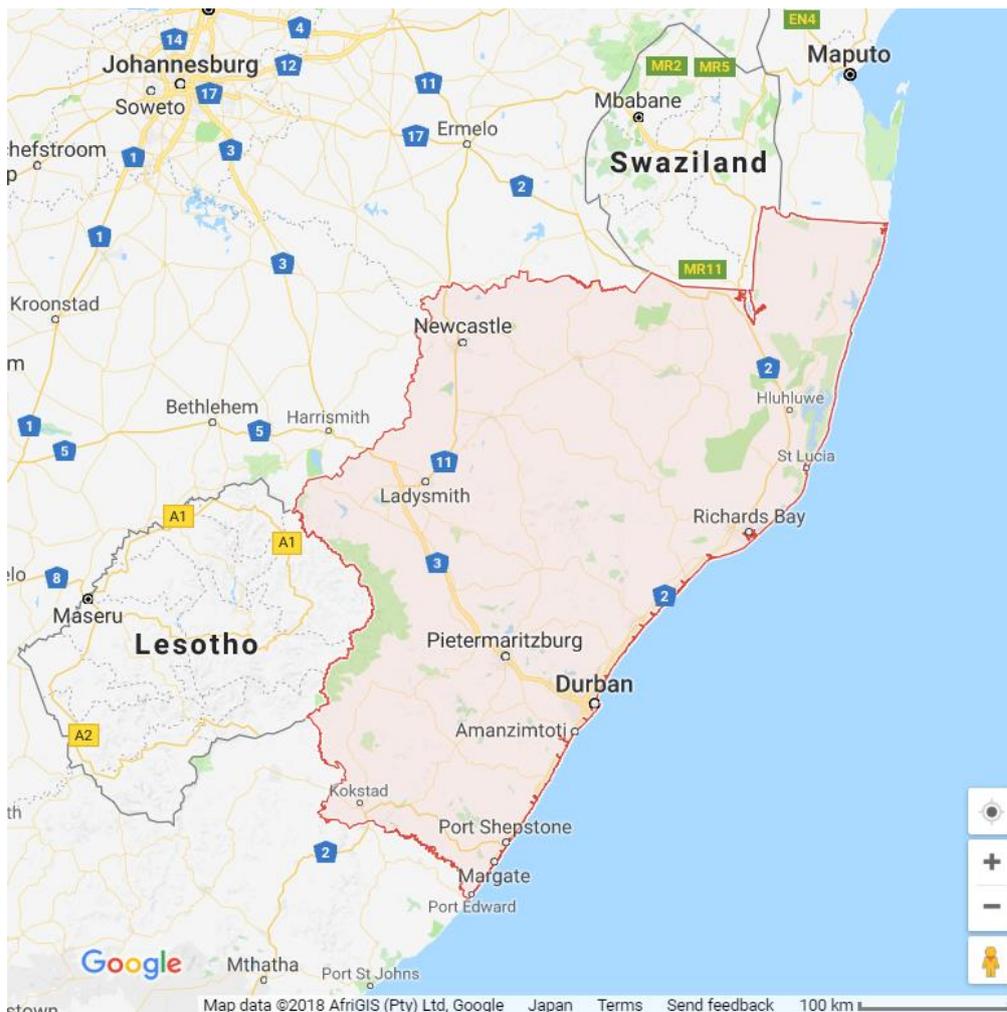
Clinical Setting:

This is a multi-national study involving a major South African trauma center and a major Japanese acute care institution.

Pietermaritzburg Metropolitan Trauma Service (PMTS):

The Pietermaritzburg Metropolitan Trauma Service provides definitive trauma care to the city of Pietermaritzburg, as well as the western third of the province of Kwa Zulu Natal. The PMTS covers a total catchment population of over three million people. It is also one of the largest academic trauma centers within the province and is responsible for both undergraduate and postgraduate training in surgery. Approximately 3000 patients are admitted per year, with approximately 50% having sustained penetrating trauma.

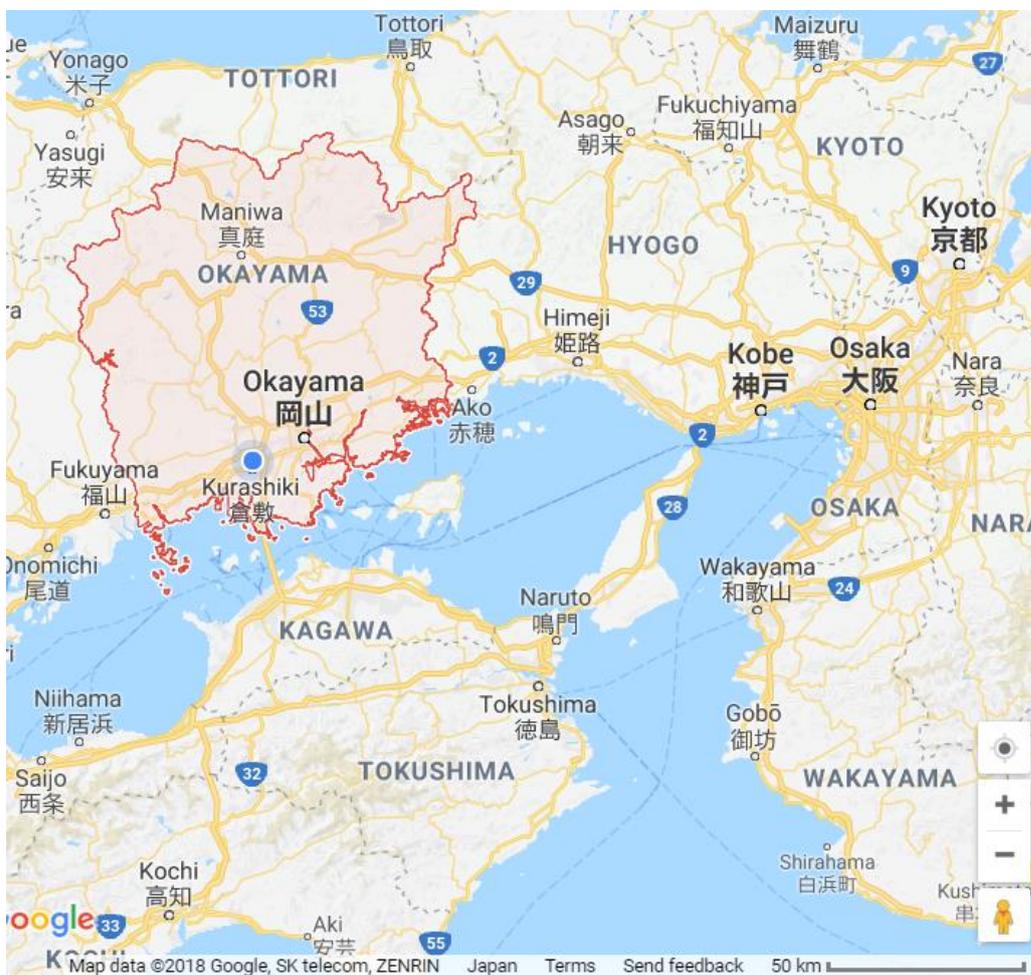
Map of the area of KwaZulu-Natal



Kurashiki Central Hospital (KCH):

Okayama prefecture is located in the west side of Japan, and Kurashiki is the second largest city in Okayama prefecture. Kurashiki Central Hospital (KCH) is a major general hospital that has 1200 beds and one of the largest emergency departments in Japan. All medical and surgical emergencies, including all trauma patients, are admitted to the department. Approximately 60,000 emergency patients are managed annually.

Map of the area of Okayama Prefecture



Ethics approval:

Ethics approval for this study was formally endorsed by the Biomedical Research Ethics Committee (BREC) of the University of KwaZulu Natal (Reference: BCA221/13, BE 207/09) and the Institutional Review Board (IRB) of Kurashiki Central Hospital.

Thesis structure:

This is a thesis by publication and comprises three chapters each containing a single publication.

The publications have either been published or are currently under review.

- Chapter 1 provides an overview of trauma workload and operative exposure in a major South African trauma center and provides a comparison with contemporary experience from major military conflict. This paper has been published in the *World Journal of Surgery*.
- Chapter 2 provides an overview of the trauma workload of a major Japanese emergency medical center and compares it with that of a major South African trauma center. The intention is to quantify and compare the time needed to gain adequate exposure to major trauma at the two centers. This paper has been published in the *European Journal of Trauma and Acute Care Surgery*.
- Chapter 3 consists of a structured survey that assesses the extent of international trauma clinical electives and the impact these have had on the career of the various foreign surgeons who undertook them.
- The conclusions chapter provides a summary of the thesis and attempts to identify a strategy that will allow us to develop structured exchange programs that will benefit both South African trainees and international surgeons.

Chapter 1:

This chapter reviews the trauma workload at the PMTS and then compares it with the trauma workload on a number of major contemporary military missions. It provides a breakdown of the surgeries and procedures that a military surgeon needs to be familiar with, and compares the military workload with the trauma load in the Pietermaritzburg Metropolitan Trauma Service (PMTS). Essentially a military surgeon must be competent to perform a laparotomy, a thoracotomy, a neck exploration, and peripheral vascular exposures as well as basic and advanced airway management and rudimentary neurosurgery. All of these procedures are performed in the PMTS in sufficient volume to be able to provide adequate pre-deployment training to a military surgeon. In light of this, it appears that the PMTS is able to prepare a military surgeon for deployment to a combat zone. Each index military procedure is seen in sufficient quantities in PMTS to ensure that a pre-deployment military surgeon may be confident that he/she has been adequately exposed to each procedure before being deployed.

Can We Train Military Surgeons in a Civilian Trauma Center?

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Abstract

Introduction The objective of this study was to review the trauma workload and operative exposure in a major South African trauma center and provide a comparison with contemporary experience from major military conflict.

Materials and methods All patients admitted to the PMTS following trauma were identified from the HEMR. Basic demographic data including mechanism of injury and body region injured were reviewed. All operative procedures were categorized. The total operative volume was compared with those available from contemporary literature documenting experience from military conflict in Afghanistan. Operative volume was converted to number of cases per year for comparison.

Results During the 4-year study period, 11,548 patients were admitted to our trauma center. Eighty-four percent were male and the mean age was 29 years. There were 4974 cases of penetrating trauma, of which 3820 (77%) were stab wounds (SWs), 1006 (20%) gunshot wounds (GSWs) and the remaining 148 (3%) were animal injuries. There were 6574 cases of blunt trauma. The mechanism of injuries was as follows: assaults 2956, road traffic accidents 2674, falls 664, hangings 67, animal injuries 42, sports injury 29 and other injuries 142. A total of 4207 operations were performed. The volumes per year were equivalent to those reported from the military surgical literature.

Conclusion South Africa has sufficient burden of trauma to train combat surgeons. Each index case as identified from the military surgery literature has a sufficient volume in our center. Based on our work load, a 6-month rotation should be sufficient to provide exposure to almost all the major traumatic conditions likely to be encountered on the modern battlefield.

Introduction

The current global geo-political situation appears to be unstable, and several major military conflicts across the world are ongoing. In addition the threat of urban terrorism

is ever present. In light of this, surgeons are expected to be competent to manage severely injured patients. This is especially the case for military surgeons who are directly deployed to conflict regions, often at short notice [1–4]. However, civilian surgeons may also suddenly be called upon to manage complex trauma patients in the aftermath of natural disasters or urban terrorism. Surgical training needs to equip surgeons with the skills to manage patients with these complex injuries. This training needs to be ongoing as without regular exposure to the management of trauma, experience is lost and surgeons gradually become less comfortable managing these patients [1–4]. However, the paradigm of surgical training has undergone enormous

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changes over the past few decades. Increasing sub-specialization means that fewer surgeons are comfortable managing injuries to multiple body cavities and multiple organ systems. This coupled with a long period of peace means that fewer surgeons have sufficient exposure and training in trauma. The Gulf war highlighted the fact that many military surgical personnel who were deployed did not have the appropriate surgical skill set to deal with the complex injuries they encountered on deployment [5]. This led to the US Congress passing legislation mandating the Department of Defense to provide trauma training in civilian hospitals [1–4]. The problem is that outside of a few major trauma centers in the USA, South Africa and Latin America very few civilian trauma services manage a sufficient volume of complex trauma to provide adequate exposure to trainees [6–8]. South Africa has a long history of providing trauma training to surgeons from around the world. However, there is little literature specifically focusing on the relevance of such civilian trauma experience to the military setting. The objective of this study was to review the trauma workload and operative exposure in a major South African trauma center and provide a comparison with contemporary experience from major military conflict.

Materials and methods

Clinical setting

This was a retrospective study undertaken at the Pietermaritzburg Metropolitan Trauma Service (PMTS), Pietermaritzburg, South Africa. Our regional electronic trauma registry, was reviewed for the 4-year period from January 2011 to December 2014. Ethics approval for this study and for maintenance of the trauma registry was formally endorsed by the Biomedical Research Ethics Committee (BREC) of the University of Kwa Zulu Natal (reference: BE 207/09 and BCA 221/13). The PMTS provides definitive trauma care to the city of Pietermaritzburg, the capital of Kwa Zulu Natal (KZN) Province. Due to the high incidence of interpersonal violence and serious crime throughout the entire province, a high volume of penetrating trauma is managed by PMTS on a daily basis.

Trauma training

The PMTS functions as part of the tertiary training system of the University of Kwa Zulu Natal (UKZN). UKZN is responsible for training undergraduate medical students as well as postgraduate surgery residents and sub-specialist trauma fellows. The PMTS faculty comprises of three dedicated sub-specialist attending trauma surgeons who

conduct all clinical and training activities. This is supported by a group of junior doctors, surgical residents in training and trauma fellows.

Trauma fellowship

The PMTS runs a structured trauma fellowship program of 24-month duration. On completion of this 2-year program, candidates are eligible to sit a sub-specialist board examination in Trauma Surgery and Surgical Critical Care. Routine patient care and surgery is undertaken by the trauma fellows and/or senior surgical residents. There is close supervision by three full-time trauma sub-specialists, of whom one is a full professor of surgery. Aside from clinical and operative training, daily 'protected teaching' is built into the program. Each morning, there is a formal structured handover session attended by all academic staff and trainees. There is a weekly trauma morbidity and mortality conference (MMC), in which all faculties and staffs attend. Attending trauma surgeon-led surgical ICU round is held daily, as well as a weekly professorial grand round. The PMTS regularly hosts the Advanced Trauma Life Support course, pioneered the Rural Trauma Team Development (RTTD) course in South Africa and is actively involved in the Definitive Surgical Trauma Skills (DSTC) courses.

Clinical activities

Within our trauma center, clinical care is provided by the trauma team. There are two such trauma teams. Each team is headed by a full-time attending trauma surgeon, along with a trauma fellow, a chief resident, a junior resident and two interns. Most surgeons who have completed their surgical residency outside of South Africa are initially placed within the team as a trauma fellow or chief resident. If sufficiently experienced, the trauma fellow can, at the discretion of the faculty, function as an acting junior attending surgeon. All operative activities are supervised by the attending trauma surgeons on duty. The chief of trauma surgery provides an overall supervisory capacity of the day-to-day activities of the center.

The study

All patients admitted to the PMTS were identified from the trauma registry. Basic demographic data, including mechanism of injury and body region injured, were reviewed. All operative procedures were categorized. The total operative volume was compared with those available from contemporary literature documenting experience from military conflict in Afghanistan. Operative volume was converted to number of cases per year for comparison.

Results

Overview

During the 4-year study period, 11,548 patients were admitted to our trauma center. Eighty-four percent were male and the mean age was 29 years.

Penetrating trauma

There were 4974 cases of penetrating trauma, of which 3820 (77%) were stab wounds (SWs), 1006 (20%) gunshot wounds (GSWs) and the remaining 148 (3%) were animal injuries. There were 7280 injuries in this cohort of patients. Table 1 summarizes the injuries according to body region injured in all 4974 patients.

Blunt trauma

There were 6574 cases of blunt trauma. The mechanism of injuries was as follows: assaults 2956, road traffic accidents 2674, falls 664, hangings 67, animal injuries 42, sports injury 29 and other injuries 142. There were 10,600 injuries in this cohort of patients. Table 1 summarizes the injuries according to body region injured in all 6574 patients.

Operative volume

A total of 4207 operations were performed. This is summarized in Table 2. In addition, a total of 1050 tube thoracostomies and 1015 central venous catheterisations were performed in the resuscitation room.

Comparative summary

Table 3 summarizes the operative case load per year for the PMTS and compares these volumes with the reported

Table 1 Penetrating blunt

Patients	4974	6574
Total injuries (n)	7280	10,600
Head	828 (11%)	4065 (38%)
Face	390 (5%)	1154 (11%)
Neck	765 (11%)	416 (4%)
Chest	2121 (29%)	1439 (14%)
Abdomen	1595 (22%)	1095 (10%)
Pelvis	162 (2%)	363 (3%)
Upper limb	813 (11%)	999 (9%)
Lower limb	606 (8%)	1078 (10%)

Table 2 Operative procedures

Operation	N = 4207
Neck exploration	134
Thoracotomy	343
Laparotomy	
Non-damage control	1196
Damage control	87
Relook	229
Laparoscopy	164
Orthopedic procedure	
Upper limb	298
Lower limb	287
Vascular exploration	
Upper limb	155
Lower limb	51
Limb amputation	36
Wound debridement	568
Fasciotomy	83
Skin grafting	127
Maxillofacial fixation	182
Neurosurgical	267

incident per year of each procedure from a number of NATO country military services and deployments.

Discussion

The ongoing state of global instability means that trauma will be a common occurrence for both military surgeons and civilian surgeons [1–4]. Due to the erratic patterns of trauma, ensuring adequate exposure of trainees to the management of trauma patients may be difficult [6–8]. This is especially the case for penetrating trauma and destructive blast injuries as both of these injury patterns are uncommon in Western Europe. This is cause for concern for military surgical services. Their staff will spend the majority of their time in civilian practice and be deployed to combat zones at short notice for short periods of time. During these deployments the learning curve may be steep as these surgeons rapidly acquire the necessary skill set. Appropriate training could flatten this learning curve associated with short notice deployment to a combat zone or a disaster area [6–8].

The use of didactic courses such as the Definitive Surgical Trauma Care (DSTC) course which combine lectures, case solving and the use of animal models has been widely propagated and provide a solid theoretical groundwork for trauma care. The use of models and mannequins is expensive, and despite all the technological developments we now take for granted, they retain an air of artificiality.

Table 3 Operative volume at different sites

Operation Country	PMTS (/year) South Africa	Hoencamp et al. (/year) Dutch	Bonnet et al. (/year) French	Ramasamy et al. (/year) British
Neck exploration	33.5	42.5	NA	97
Thoracotomy	85.75	5.5	16	16
Laparotomy				
Non-damage control	299	45.5	42	53
Damage control	21.75	31.25	NA	NA
Laparoscopy	41	NA	NA	NA
Orthopedic procedure	146.25	92.25	NA	NA
Vascular exploration	51.5	5.25	10	13
Limb amputation	9	31.5	NA	43
Wound debridement	142	231.25	17	NA
Fasciotomy	20.75	15.25	NA	23
Skin grafting	31.75	28.25	NA	23
Maxillofacial fixation	45.5	NA	NA	NA
Neurosurgical	66.75	NA	NA	20

The need for practical experience in real-life trauma care remains essential for the development of the necessary skill set of a military and a civilian trauma surgeon. Professor Schwab eloquently alluded to this when he delivered the first U.S. Army Major John P. Pryor Lecture at the American College of Surgeons Meeting in San Francisco [8]. His message was that military surgical training has to be coordinated between the armed services and civilian trauma centers. The problem remains that even in North America few trauma centers see the volume of trauma necessary to train combat surgeons [1–4].

It would appear from our data that our volume of trauma is sufficient to provide adequate exposure to all the procedures which a combat surgeon will be expected to manage. In the case of thoracic trauma, the British military experience documented 826 patients with thoracic trauma over an eight-year period, of which 106 (12%) required a thoracotomy. This is a similar rate to the civilian experience in South Africa where over a four-year period the PMTS managed 1239 patients with thoracic trauma of which 112 (9%) required a thoracotomy [9, 10]. The majority of the military patients had sustained a blast-type injury which was different to the civilian series. The mortality rate for thoracotomy in the military setting was much higher than in the equivalent civilian experience (45%) compared to (16%). This reflects the more destructive nature of war wounds. The authors of this report emphasized the fact that general surgeons who were expected to manage military trauma had not had sufficient exposure to thoracic surgery during their civilian training. Our data suggest that although the injury pattern differs between military and civilian thoracic trauma, we have

sufficient volumes of thoracic trauma to provide trainees with adequate exposure to emergency thoracic surgery.

In another report from the British military, the authors retrospectively reviewed operating theater records for a 2-year period. They identified 1668 cases which required a total of 2210 procedures. They reported that the breakdown of procedures, by specialty, was 66% (1463) orthopedic, 21% (465) general surgery, 6% (139) head and neck, 5% (104) burns surgery and a further 4% (50) non-battle, non-emergency procedures. The authors went on to state that a 6-week deployment to Helmand Province provided an equivalent exposure to penetrating trauma as a 3-year civilian experience in Britain. In light of this, they felt that the requisite skill set required by a military surgeon was outside the exposure which could be obtained in British civilian practice [9]. Other military surgical services have reported similar findings [11–16]. It would appear from our data that the exposure to the trauma skill set required by a trauma surgeon can be adequately met in our service and the rotation of military surgeons through such an environment should be encouraged.

Whilst clinical experience is essential, close attention needs to be paid to the academic training of a trauma or combat surgeon [1]. This requires adequate academic supervision coupled with rigorous case review and reflection. This critical reflection needs to be made manifest by academic output and presentation and ultimately by some sort of benchmarking by a formal academic examination. In addition to the appropriate volume and spectrum of trauma to train a combat surgeon in terms of practical- and procedural-based skills, we have the academic infrastructure to ensure that this training is truly academic [17, 18].

The PMTS has a highly qualified faculty who are active at all academic levels both nationally and internationally. There is an established academic program of morbidity and mortality meetings. There is a robust and proven electronic surgical registry which allows for formal tracking of morbidity and outcomes. This serves to improve patient care and to allow for academic publications and presentations [19–21].

The certificate in trauma and critical care which is offered by the College of Surgery of South Africa is a board-type sub-specialist examination and provided all the academic and practical requirements are met it would be appropriate for foreign-qualified surgeons to sit this examination. In addition active participation in well-established courses such as the American College of Surgeons accredited Advanced Trauma Life Support (ATLS) course and Rural Trauma Team Development (RTTD) course as well as the Definitive Surgical Trauma Care (DSTC) course means that all faculties are current with international best practice and training [22].

Integrating a visiting trauma fellow into a busy system such as ours is feasible and has in fact been practiced for a number of years [23]. If a more formal system was implemented and a memorandum of understanding developed between UKZN, the Department of Health and the respective military service, it would allow for a more structured approach to training of both our local staff and the visiting trainees and surgeons.

Conclusion

South Africa has a sufficient burden of trauma to train combat surgeons. Each index case as identified from the military surgery literature has a sufficient volume in our service. Based on our workload, a 6-month rotation should be sufficient to provide exposure to almost all the major traumatic conditions likely to be encountered on the modern battlefield. In addition our center and other South Africa training centers have sufficient academic support and capacity to ensure such training is academically sound. Integrating military surgery into South Africa surgical training would allow for the development and strengthening of academic linkages between South African surgical training services and international units.

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Chapter 2:

This chapter builds on work undertaken in chapter one. It applies a similar methodology to quantify the trauma exposure of a Japanese surgeon working at a major trauma center in Japan and to review the process of trauma training in Japan. The trauma system in Japan is designed to meet the needs of the country. As such, it is focused on the management of blunt trauma. The exposure of Japanese surgeons to the management of penetrating trauma and blast injury is limited. This means that in the event of a major urban terror attack or a major military operation, it is unlikely that Japanese trained surgeons will be comfortable managing these types of casualties. The concept of sending select individuals to undertake a trauma elective in South Africa and then to use their expertise to leverage trauma training and preparedness in Japan is discussed.

Preparing Japanese surgeons for potential mass casualty situations will require innovative and systematic programs

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Abstract

Introduction The ongoing state of global geo-political instability means that it is prudent to prepare civilian surgeons to manage major military-type trauma. Japan has enjoyed a prolonged period of peace and consequently it is unlikely that surgeons will have been exposed to a sufficient volume of cases. This study reviews the state of trauma training and preparedness in Japan and reviews the trauma workload of a major Japanese emergency medical center and compared with a major South African trauma center with the intention of quantifying and comparing the time needed to gain adequate exposure to major trauma at the two centers.

Materials and methods The literature describing the surgical burden from a number of recent military missions was reviewed and the core surgical skills to manage military-type injuries were identified. We then went on to review all patients admitted to both Kurashiki Central Hospital (KCH) and Pietermaritzburg Metropolitan Trauma Service (PMTS) following trauma between the period September 2015 and August 2016. The burden of trauma at each center was quantified and the number of core surgical competencies and procedures performed at each center was then reviewed. These were then compared with the number of the core procedures which were performed on the reported military missions.

Results Three reports on military surgical missions were reviewed. These came from the Dutch, French and British military surgical services. The average number of each core procedures performed on each reported military surgery mission are tabulated in the text. The most common procedures were wound debridement and orthopedic fixation, followed by trauma laparotomy, neck exploration and thoracotomy. During the 12 month study period, 309 trauma patients were admitted to KCH. Of which 206 (67%) were male, and the mean age was 57 years. There were 10 penetrating injuries and 299 blunt injuries. Of the penetrating injuries there were no gunshot wounds. The mechanisms of injury for blunt trauma were as follows: Road traffic accidents (RTAs); 141 (47%), fall; 136 (46%) and other injuries; 22 (7%). In the same period, 2887 trauma patients were admitted by the PMTS. There were 1244 cases (43%) of penetrating trauma and 1644 cases (57%) of blunt trauma in PMTS. The mechanisms of injury for penetrating trauma were as follows: stab wounds (SWs); 955 (77%), gunshot wounds (GSWs); 252 (20%), and other injuries; 37 (3%) and for blunt trauma were as follows: assault; 739 (45%), RTAs; 669 (41%), fall; 166 (10%), and other injuries; 70 (4%). The exposure to all the key competencies required to manage

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trauma is overwhelmingly greater in South Africa than in Japan. The length of time needed to obtain an equivalent trauma exposure to that achieved in South Africa, working in Japan is prohibitively long.

Conclusion Trauma training in Japan is hamstrung by a lack of clinical material as well as by systematic factors. Training a trauma surgeon is difficult. Developing a trauma system in the country may help address some of these deficits. South Africa in contrast has a huge burden of trauma and sufficient infrastructure to ensure that surgeons working there have adequate exposure to major trauma. Developing an academic exchange program between Japan and South Africa may allow for the transfer of trauma experience and skills between the two countries.

Keywords Trauma surgical training · Core surgical skills · Trauma system · Exchange program

Introduction

The global geo-political situation appears to be in a state of flux. There are several ongoing military conflicts around the globe. The alliances as well as long standing balances of power both regionally and globally appear to be shifting. The scourge of urban terrorism is raising its head in increasing numbers of major cities which have known relative peace for over seventy years. The implication is that even civilian healthcare services are required to be prepared for a broad range of casualties at unexpected times. Since the end of the Second World War, Japan has not been involved in any military operations and has only operated a self-defense force rather than a conventional military force [1]. However, Japan currently faces a number of existential threats in the form of potential regional conflicts and urban terrorism. It may come to pass that Japan is called upon to respond to a mass casualty situation either from urban terrorism, or a major regional military conflict. Civilian surgical services therefore need to be prepared to manage large volumes of major trauma victims at short notice.

This raises the issue of how to ensure that busy civilian surgeons have appropriate surgical trauma training. Globally, the modern surgeon is increasingly sub-specialized and focused on complex elective operations in a well-controlled environment. Non-operative management and minimally invasive surgery have become more common for a number of acute surgical conditions. Preparing a modern surgeon to manage mass shooting or terrorist related injuries remains an ongoing challenge in many countries [2–7]. The literature from recent military missions has highlighted a number of core surgical skills which trauma surgeon must be au fait with [8–14]. In the event of a major terrorist incident, civilian surgeons, who may be confronted with similar patients,

will need to be competent in terms of these key skills. There is no consensus on how many of these key skills a surgeon needs to see or perform to achieve competence.

Following the events of September 11, 2001, the primary author realized that exposure to major trauma is essential and consequently worked for a year with the Pietermaritzburg Metropolitan Trauma Service (PMTS) in Pietermaritzburg, South Africa. Following this he periodically returned for a shorter period and began working on a project to help formalize and consolidate trauma training in Japan. This paper contrasts the trauma workload of a major Japanese emergency medical center, with that of the PMTS as well as with a number of contemporary military deployments. By objectively quantifying the length of clinical time needed to be exposed to the core surgical skills needed to manage major trauma, it is hoped that we will be able to develop norms for achieving and maintaining competency in these core skills. Ultimately, development of both curricula and exchange programs may allow for better preparation of civilian surgeons who may be called upon to care for the victims of a major urban terrorist incident.

Materials and methods

Clinical settings

Kurashiki Central Hospital (KCH)

Okayama prefecture is located in the west side of Japan and Kurashiki is the second largest city in Okayama prefecture. Half a million people reside in the city of Kurashiki. Kurashiki Central Hospital (KCH) is a major general hospital which has 1200 beds and has one of the largest emergency departments in Japan. The hospital serves a population of covers over 800,000 people from the west side of Okayama prefecture. All medical and surgical emergencies, including all trauma patients are admitted to the department. Approximately 60,000 emergency patients are managed annually. The emergency department is managed by specialist emergency physicians. All trauma patients are initially assessed by the emergency physicians and once the trauma team protocol has been activated, trauma surgeons provide all definitive trauma care. However, there are no dedicated trauma fellows or residents and patients are admitted and managed by emergency physicians. Patients with isolated traumatic brain injury or isolated orthopedic trauma requiring admission are managed by the respective specialties.

Pietermaritzburg metropolitan trauma service (PMTS)

The province of Kwa-Zulu Natal (KZN) is on the eastern seaboard of South Africa. Pietermaritzburg is the capital

city and is situated one hour inland from the urban conurbation of Durban. A million people reside in the city of Pietermaritzburg. The PMTS provides definitive trauma care to the city of Pietermaritzburg, as well as the western third of the province. The PMTS covers a total catchment population of over three million people. It is also one of the largest academic trauma centers within the province. Due to the extremely high incidence of interpersonal violence, gang related and criminal activities throughout the entire province, approximately 3000 patients are admitted per year, with around 50% penetrating trauma. The PMTS functions with a trauma team, which is headed by a duty full-time trauma surgeon, along with a trauma fellow, a chief resident, a junior resident, and a number of interns. Almost all patients are managed by the trauma team, with the exception of those with isolated orthopedic trauma. The only patients that require transfer out of our trauma center are those with traumatic brain injuries requiring surgical intervention, in which the neurosurgical unit is located at Inkosi Albert Luthuli Central Hospital (IALCH) in Durban.

The study

Ethics approval for this study was formally endorsed by the Biomedical Research Ethics Committee (BREC) of the University of Kwa Zulu Natal (BCA221/13, BE 207/09) and the Institutional Review Board (IRB) of Kurashiki Central Hospital. The literature describing the surgical burden from a number of recent military missions was reviewed and the core surgical skills to manage military-type injuries were identified. We then went on to review all patients admitted to both KCH and PMTS following trauma between the period September 2015 and August 2016 using the respective electronic databases and compared. Following this, the burden of trauma at each center (KCH and PMTS) was quantified and the number of key surgical skills or procedures performed at each center was reviewed. Basic demographic data, including mechanism of injury and body region injured were reviewed and all operative procedures were categorized. Operative volume was calculated for each center and reported as number of key skills per year. This was then compared to the published military data.

Military data

A comparison with published data on recent military surgical missions was undertaken. The literature describing the surgical burden from a number of recent military missions was reviewed and the core surgical skills to manage military-type injuries were identified. Papers which focused on specific injuries such as vascular, thoracic or colorectal trauma were rejected in favor of papers presenting a broad review of the general trauma workload at the most forward type of

military medical facilities. These reports were analyzed and the reported workload noted. As was done with the KCH and PMTS data, an attempt was made to quantify the reported military workload into key skills by year. These were then compared to the workload for each key skill by year for KCH and PMTS.

Results

The KCH cohort

During the 12 month study period, 309 trauma patients were admitted to KCH; 206 (67%) were male, and the mean age was 57 years. There were 10 penetrating injuries and 299 blunt injuries. Of the penetrating injuries, there were no gunshot wounds (GSWs). The mechanisms of injury for blunt trauma were as follows: road traffic accidents (RTAs); 141 (47%), fall; 136 (46%) and other injuries; 22 (7%).

The PMTS cohort

During the same 12 month period, 2887 patients were admitted by the PMTS. There were 1244 cases (43%) of penetrating trauma and 1644 cases (57%) of blunt. The mechanisms of injury for penetrating trauma were as follows: stab wounds (SWs); 955 (77%), GSWs; 252 (20%), and other injuries; 37 (3%). The mechanisms of injury for blunt trauma were as follows: assault; 739 (45%), RTAs; 669 (41%), fall; 166 (10%), and other injuries; 70 (4%). Table 1 compares the mechanism of trauma in the KCH cohort and the PMTS cohort and estimated length of time needed to obtain the equivalent trauma exposure in KCH. Table 2 compares the number of injuries for each mechanism in Japan and South Africa according to body region.

Table 1 Mechanism of trauma and the length of time needed to obtain the equivalent trauma exposure in Japan

	Japan/year	South Africa/year	Requiring years to obtain (years)
Total (n)	309	2887	9.3
Penetrating	10	1244	124.4
Gunshot wounds	0	252	252
Stab wounds	9	955	106.1
Other	1	37	37
Blunt	299	1644	5.5
Road traffic accident	141	669	4.7
Fall	136	166	1.2
Assault	0	739	739
Other	22	70	4.4

Table 2 Number of injuries for each mechanism

	Japan/year		South Africa/year	
	Penetrating	Blunt	Penetrating	Blunt
Total injuries (n)	13	597	1821	2654
Head	0 (0%)	144 (24%)	207 (11%)	1016 (38%)
Face	0 (0%)	38 (6%)	98 (5%)	289 (11%)
Neck	1 (8%)	47 (8%)	191 (11%)	104 (4%)
Chest	1 (8%)	132 (22%)	530 (29%)	360 (14%)
Abdomen	6 (46%)	64 (11%)	399 (22%)	274 (10%)
Pelvis	1 (8%)	53 (9%)	41 (2%)	91 (3%)
Upper limb	2 (15%)	63 (11%)	203 (11%)	250 (9%)
Lower limb	2 (15%)	56 (9%)	152 (8%)	270 (10%)

Operative exposure

Three reports on military surgical missions were reviewed. These came from the Dutch, French and British military surgical services. The most common procedures were wound debridement and orthopedic fixation, followed by trauma laparotomy, neck exploration and thoracotomy. Table 3 summarizes the number of procedures performed each year in KCH and PMTS and then compares them to the published burden from three different national military surgical missions. Table 4 attempts to establish the length of time needed to achieve clinical exposure to the key operative competencies in KCH and PMTS.

Table 3 Number of procedures performed each year and comparison with published literature

Operations /year	Operations /year				
	Japan	South Africa	Dutch (12–14) Hoencamp et al.	French (9) Bonnett et al.	British (10) Ramasamy et al.
Neck exploration	0	34	43	NA	97
Thoracotomy	7	86	6	16	16
Laparotomy—non damage control	16	299	46	42	53
Laparotomy—damage control	8	22	31	NA	NA
Laparoscopy	2	41	NA	NA	NA
Orthopedic procedure	17 (Ex-fix)	146	92	NA	NA
Vascular exploration	3	52	5	10	13
Limb amputation	2	9	32	NA	43
Wound debridement	8	142	231	17	NA
Fasciotomy	NA	21	15	NA	23
Skin grafting	2	32	28	NA	23
Maxillofacial fixation	NA	46	NA	NA	NA
Neurosurgical	NA	67	NA	NA	20

Table 4 The length of time needed to achieve clinical exposure to the key operative competencies in Japan

	Operations/year		Requiring years to obtain (years) Japan
	Japan	South Africa	
Neck exploration	0	34	34.0
Thoracotomy	7	86	12.3
Laparotomy—non damage control	16	299	18.7
Laparotomy—damage control	8	22	2.8
Laparoscopy	2	41	20.5
Orthopedic procedure	17 (Ex-fix)	146	8.6
Vascular exploration	3	52	17.3
Limb amputation	2	9	4.5
Wound debridement	8	142	17.8
Fasciotomy	NA	21	NA
Skin grafting	2	32	16.0
Maxillofacial fixation	NA	46	NA
Neurosurgical	NA	67	NA

Discussion

In our comparative study of two major trauma centers in Japan and South Africa, it would appear that the volume of trauma in Japan is relatively limited for civilian surgeons to gain sufficient exposure. The significant difference between the two major trauma centers in Japan and South Africa is almost ten times. Furthermore, penetrating trauma is also rare in Japan. One year in PMTS provided an equivalent exposure to penetrating trauma that one would otherwise require 124 years to gain in KCH. Furthermore, the number of major operative procedures (e.g. neck exploration, vascular exploration, laparotomy, etc.) would require over fifteen years to acquire. Practical exposure to the management of trauma patients is essential if one hopes to train civilian surgeons with the necessary skill set to manage these injuries. Didactic courses such as the Definitive Surgical Trauma Care (DSTC) course which combines lectures, case solving and the use of animal models has recently been introduced in Japan. Although this course provides a solid theoretical background for trauma care, slots with places on the course are still limited.

A similar situation is likely to exist in other Asian and Western European countries. These "peaceful countries" simply do not have sufficient trauma to ensure that those managing it develop and maintain the appropriate surgical skill set. However, the current unstable global situation is replete with potential threats of war and urban terrorism. This means that even in these countries surgeons may suddenly and unexpectedly be required to deal with military-type injuries. In light of this, it is imperative that countries develop comprehensive response systems capable of managing a sudden unexpected demand for trauma care. An effective system requires preparedness, which means regular major trauma exercises. The limited trauma exposure makes it difficult to train trauma surgeons and to develop an adequate trauma team or system capable of dealing with future calamities. South Africa historically has a high burden of trauma [15]. Its burden of interpersonal violence and penetrating trauma is amongst the highest in the world. South Africa has a well-developed surgical training system with a track record of providing both academic and clinical trauma training to surgeons from around the world.

In Japan, the low level of clinical exposure to major military-type trauma is exacerbated by the disparate nature of the trauma system. Although the low burden of trauma in Japan should make it easier to concentrate trauma patients at a designated trauma center, each of which covers a population of 2–3 million people, this has not been done. In Tokyo, there are more than twenty-five emergency centers for a population of 13 million people [16, 17]. This translates into one emergency center per 520,000 population. In addition, trauma patients are dispersed to smaller

hospitals and facilities, thus further diluting the number of trauma patients presenting at the major emergency centers. There is currently no verification system for trauma centers in Japan. This is in contrast to the situation in the United States of America where trauma centers are ranked by the American College of Surgeons, from Level 1 which provides a comprehensive service to Level 3 center which provides a lower level of trauma care [18]. The different levels also take account of resources available in each institution and the number of patients admitted per annum. These categories define national standards for trauma care in hospitals and trauma centers are regularly re-verified.

In addition to the lack of trauma center verification in Japan, there is currently no board type sub-specialty qualification for trauma surgery. There is a lack of early surgical input into trauma care. Trauma care is often administered primarily by emergency physicians without the appropriate involvement of trauma surgeons capable of delivering definitive care. When surgeons are involved, they are usually gastrointestinal or cardiovascular surgeons who are not primarily trained to manage severely injured patients. For historical reasons, the Japanese Surgical Society has not been involved in planning for trauma management and no specific trauma surgical training program exists. Whilst the current system appears to be adequate to manage low volumes of predominantly blunt trauma, in the event of a major terrorist incident the system may not be resilient enough to manage the sudden influx of major trauma patients with military-type injuries. Planners need to strategize around this problem as recent events have shown that cities which have enjoyed long periods of peace are now at risk for major unexpected mass terror events.

One potential solution is the development of clinical fellowships and exchange programs which allow surgeons from countries such as Japan to spend time in high volume trauma centers either in South Africa or North America [5]. It must, however, be understood that modern trauma care is a team effort. The archetypal modern war injury is a blast injury and managing these complex injuries requires input from a diverse group of people. These include orthopedic, plastic, urological, burn and general surgeons as well as intensivists and anesthetists. In addition, allied medical staff such as emergency nurses, respiratory and physiotherapists and occupational therapists all play essential roles in the acute care and rehabilitation of these patients. This means that exposing a single surgeon to trauma in a high-volume center will not ensure the development of a collective institutional knowledge of trauma management at the parent institution. If an exchange program is set up it must look to send a broad range of staff to the high-volume training center. In addition, programs at the parent institution must be set up under the leadership of staff who have attended the high-volume center to

ensure that the trauma skills they acquired are passed on to these institutions.

This study has a number of limitations, which include the fact that there are no nationwide data available to compare the overall trauma experience between the two countries, and the only military data available are those which have been reported in the literature. In addition, there is little consensus on the number of each of these key skills which needs to be seen and managed before a surgeon can be considered to be clinically competent. It is hoped that this paper may provide a stimulus to more meaningful planning and data collection. As stated in the introduction, the global geopolitical situation seems to be extremely tense and replete with potential and actual conflicts. For this reason, endeavors such as the one described in this article are of the utmost importance. It may well be that major relief organizations as well as various military medical services need to collaborate to attempt to co-ordinate such a project.

Conclusion

Trauma training in Japan is hamstrung by a lack of clinical material as well as by systematic factors. Training a trauma-competent military or civilian surgeon in such an environment is difficult. Developing a trauma system in the country may help address some of these deficits. In addition, developing academic exchange programs with countries which can offer broader trauma experience is essential, however, it is important to integrate these skills back into a trauma system once the individual returns to Japanese practice.

Compliance with ethical standards

Conflict of interest No conflict of interest declared. VK, GO, WB, GL, JB, DC are all Advanced Trauma Life Support (ATLS) Instructors. HU, GO, JB, DC are also DSTC instructors.

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Chapter 3:

This chapter consists of a survey of international surgeons who have undergone a trauma elective in South Africa. It describes their demographics and goes on to interrogate the influence the elective had on their clinical competence. It attempts to examine how their exposure in South Africa impacted their subsequent careers in their base countries. It provides some suggestions as to how these electives can be formalized and used as leverage to develop other areas of South African surgical training. It has been accepted for publication in the *South African Medical Journal*.

Publication 3

Uchino H, Kong VY, Clarke DL, Bruce JL, Laing GL, Plani F.

Trauma electives in South Africa provide valuable training for international surgeons.

This article has been accepted by *South African Medical Journal*. 2018

Abstract:

Introduction

This study aims to investigate and document the extent of trauma clinical electives and to assess the impact these had on the career of the various foreign surgeons who undertook them.

Methods

A mixed methods style questionnaire was compiled which sought to document the demographics of the surgeons undertaking a South African trauma clinical elective, the clinical experience in trauma which they had prior to the elective as well as the volume of experience they acquired during their elective.

Results

A total of 60 questionnaires were sent out and twenty-one were completed. Of the respondents there were 16 males and 5 females. Only 17 had undertaken a formal trauma rotation prior to their elective in South Africa. The mean number of major resuscitations managed prior to rotating through South Africa was 15 and the mean number managed during a 12 months rotation in South Africa was 204. It would take each respondent 14 years in their country of origin to acquire an equivalent level of exposure to major resuscitation. The mean number prior to their elective each surgeon had been exposed to 0.5 gun-shot wounds (GSWs) per year, 2 stab wounds (SWs), 0.1 blast injuries and 19 road traffic accidents (RTAs). The equivalent mean for their year in South Africa was 106 GSWs, 153 SWs, 4 blast injuries and 123 RTAs. The time necessary to achieve a similar level of exposure to their South African experience if they had remained in their country of origin was 213 years for GSWs, 73 years for SWs, 41 years for blast injuries and 7 years for RTAs. It would take each respondent 3 years to insert as many central venous lines, 9 years for tube thoracostomies, 9 years to perform as many surgical airways, 18 years to explore as many SW of the neck and 93 years to explore as many GSW of the neck as they did during their South African elective. The same applies to laparotomies for trauma. It would take 33 years to see and perform as many laparotomies for GSWs to the abdomen and 374 years to perform an equivalent number of GSW abdomens in their countries of origin. In addition, it would require 34 years-experience to perform as many damage control laparotomies. In terms of vascular trauma, it would take 23 years to see as many vascular injuries secondary to SW and 77 to see an equivalent number of vascular injuries secondary to a GSW.

Conclusion

A clinical elective in trauma in South Africa provides an un-paralleled exposure to almost all forms of trauma in conjunction with a well-developed academic support program. Formalizing these

trauma electives may allow for the development of exchange programs for South African trainees who wish to acquire international exposure to advanced general surgical training.

Introduction

As surgery has advanced over the last several decades the need for sub-specialist training programs has increased. Increasingly, general surgical residency programs do not seem to be able to provide trainees with the complete set of skills necessary to manage the modern surgical patient holistically. This has led to the development of sub-specialist programs both in South Africa and around the world. (1, 2) These are usually referred to as fellowships. In South Africa and in the United States surgical fellowships may allow for the trainees to obtain a formal sub-specialist qualification at the end of the rotation. Many trainees do not sit the formal sub-specialist examination but will undertake the fellowship for the practical and clinical exposure. These are sometimes termed 'clinical electives' to distinguish them from formal fellowships. International clinical electives are increasingly popular and many surgeons will attempt to spend a year or two, in a foreign environment at some point during their careers. There are many reasons for this, which include social intangibles such as travel and exposure to foreign cultures and environments, as well as ones pertaining to clinical practice. South African trauma experience and trauma training remain highly thought of around the world. The huge burden of trauma in South Africa combined with access to modern surgical resources, underpinned by a strong academic foundation has made a clinical elective in a South African trauma center an important part of many trauma surgeon's training. (3-6) Over the last three decades numerous foreign based surgeons at a variety of levels of training have undertaken a clinical elective in trauma in South Africa. Despite the popularity of these clinical electives, they remain un-formalized and relatively unstructured and there has been almost no academic review of their impact and role. This study aims to investigate and document the extent of these trauma clinical electives and to assess the impact these had on the career of the various foreign surgeons who undertook them.

Methods

A mixed methods style questionnaire was compiled which sought to document the demographics of the surgeons undertaking a South African trauma clinical elective as well as the clinical experience in trauma which they had prior to the elective as well as the volume of experience they acquired during their elective. The survey is attached in appendix 1.

Results

A total of 60 questionnaires were sent out and twenty-one were completed. Of the respondents there were 16 males and five females. The country of origin of each trainee is shown in Table 1. There were 17 general surgeons, 3 emergency physicians and 1 pediatric surgeon amongst the respondents. When asked about current subspecialty interests these were trauma and critical care (4), vascular surgery (5), cardiac surgery (1), colorectal surgery (1), emergency medicine (2), hepato-biliary surgery (1), general surgery (1), intensive care medicine (2) and urology (1). Of the respondents only 17 had undertaken a formal trauma rotation prior to their elective in South

Africa. In only 3 cases was this rotation at a Level 1 trauma center as defined by the American College of Surgeons (ACS). Of the respondents, 17 felt that their career had benefited as a result of their clinical elective. The mean number of major resuscitations managed prior to rotating through South Africa was 15 and the mean number managed during a year rotation in South Africa was 204. It would take each respondent 14 years in their country of origin to acquire an equivalent level of exposure to major resuscitation. On mean in the year prior to their elective each surgeon had been exposed to 0.5 gun-shot wounds (GSWs), 2 stab wounds (SWs), 0.1 blast injuries and 19 road traffic accidents (RTAs). The equivalent mean for their year in South Africa was 106 GSWs, 153 stab wounds 4 blast injuries and 123 RTAs. The time necessary to achieve a similar level of exposure to their South African experience if they had remained in their country of origin was 213 years for GSWs, 73 years for SWs, 41 years for blast injuries and 7 years for RTAs. Table 2 summarizes the pre-rotation and post-rotation exposure to different types and mechanisms of trauma of the 21 respondents. It would take each respondent 3 years to insert as many central venous lines, 9 years for tube thoracostomies, 9 years to perform as many surgical airways, 18 years to explore as many SW of the neck and 93 years to explore as many GSW of the neck as they did during their South African elective. The same applies to laparotomies for trauma. It would take 33 years to see and perform as many laparotomies for GSW's to the abdomen and 374 years to perform an equivalent number of GSW abdomens in their countries of origin. In addition, it would require 34 years-experience, to perform as may damage control laparotomies. In terms of vascular trauma, it would take 23 years to see as many vascular injures secondary to a SW and 77 years to see an equivalent number of vascular injuries secondary to a GSW. Table 3 summarizes the exposure each trainee had to procedures in trauma prior to and post their elective in South Africa. In the final column of each table is an estimated length of time it would have taken to achieve this level of clinical exposure if these surgeons had not undertaken a clinical elective in South Africa.

Discussion

Trauma training and trauma preparedness is increasingly an area of concern around the world. Formal military conflicts over the last two decades have ensured that most military surgeons have been exposed to significant volumes of trauma. This experience is reflected in the large body of literature which have emerged from these conflicts. (5,11-13) Currently it would appear that whilst these formal conflicts are over, some form of asymmetric warfare is likely to continue for the immediate future. This era of asymmetric warfare means that trauma may occur in un-expected areas away from the formal frontlines of conflict, as evidenced by the spread of urban terrorism, which has over the last five years has blighted many major European cities. (7-9) In addition ongoing social changes such as mass migration and ongoing urban poverty means that interpersonal trauma is once again on the rise in major European cities. (7-9) This means that trauma preparedness is a major concern. It is up to surgeons and emergency physicians around

the world to ensure that they have sufficient experience and institutional knowledge to treat major trauma.

There has been a response to this challenge and countries such as Australia have sought to adopt guidelines such as the current Tactical Combat Casualty Care (TCCC) Guidelines, and the Joint Trauma System (JTS) of the US Army Institute of Surgical Research. (10-13) Other countries have followed suit in this. However, despite the widespread introduction of military style training systems, which seek to impart the experience gained during the recent major conflicts to civilian practitioners, the reality is that in countries in western Europe and Australasia there is a low rate of penetrating and ballistic trauma. This means that it is difficult for emergency staff to obtain real life clinical experience in the management of these injuries.

South Africa after twenty-five years of democracy remains a country of contrasts. (3,4) It has a sophisticated infrastructure yet is plagued by huge socio-economic disparities and a stubbornly persistent high burden of trauma. This heavy burden of trauma has allowed South African trauma surgeons to obtain huge volumes of experience in the management of trauma and South African trauma surgeons have acquired an international reputation for excellence. This experience has been documented in a sustained output of publications dating back over the last sixty years. (3,4,14) In addition the development of Trauma as a sub-specialty and the ongoing drive to accredit Trauma Centers in the country has ensured that South African trauma care continues to be held in high esteem across the world. This unique combination of clinical load, infrastructure and academic output is what makes a clinical elective in trauma in so attractive to a foreign surgeon.

If these trauma electives are to be used as leverage to develop and enhance South African surgical training as a whole, they may well need to be formalized. Currently the situation is somewhat anomalous in that South African institutions provide training to other countries and receive no formal remuneration. Apart from the intangibles such as reputation and good will, these electives provide no sustainable systematic benefit to South African institutions. This is short sighted as there are many potential benefits. These include access to advanced laparoscopic and transplant training for South African trainees who will be able to rotate through international centers of excellence. (15) The formal development of research links may also allow South African institutions to increase their access to major international collaborative funding and to laboratory-based research.

Conclusion

A clinical elective in trauma in South Africa provides an un-paralleled exposure to almost all forms of trauma in conjunction with a well-developed academic support program. The trainees who completed such an elective all felt that the clinical exposure was of inestimable value. Formalizing

these trauma electives may provide South African training programs with international exposure and allow for the development of exchange programs for South African trainees who seek advanced general surgical training abroad.

Table 1. Country of origin.

Japan	5
Sweden	5
United Kingdom	3
Belgium	1
New Zealand	1
The Netherlands	1
India	1
Democratic Republic of the Congo	1
Gabon	1
Ghana	1
Kenya	1

Table 2. Pre-rotation and post-rotation exposure to different types and mechanism of trauma.

	Prior Exposure (Avg/Year)	Exposure during SA elective (Avg/Year)	Estimated number of years to acquire the same level of experience in country of origin.
Major Trauma Resuscitation	15	204	14
Gunshot wound	0.5	106	213
Stab Wound	2	153	73
Blast Injury	0.1	4	41
Road Traffic Accidents	19	123	7

Table 3. pre-rotation and post-rotation exposure to procedure.

	Prior to SA (Avg/Year)	During SA (Avg/Year)	Years to obtain
CVP Line	9.8	29.2	3
Chest Tubes	5.9	50.1	9
Intubation	14.5	17.9	1
Surgical Airway	0.4	3.4	9
Neck Exploration - SW	0.3	5.4	18
Neck Exploration - GSW	0.03	2.8	93
Neck Exploration - Blunt	0.08	0.3	4
Thoracotomy - SW	0.2	12.6	63
Thoracotomy - GSW	0.02	3.7	185
Thoracotomy - Blunt	0.5	2.9	6
Laparotomy - SW	1	33.3	33
Laparotomy - GSW	0.07	26.2	374
Laparotomy - Blunt	1.3	12.5	10
Damage Control Laparotomy	0.7	23.9	34
Peripheral Vascular Trauma - SW	0.3	7	23
Peripheral Vascular Trauma - GSW	0.07	5.4	77
Peripheral Vascular Trauma - Blunt	0.3	2	7

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Conclusions

Currently, the global geo-political situation appears to be in a state of flux. Ongoing military conflicts around the globe and the scourge of urban terrorism are increasing in major cities. The implication is that even civilian surgeons in peaceful countries must be prepared to manage unexpected large volumes of major trauma victims on short notice. These trauma victims may very well sustain military type injuries. This was certainly the case during the Paris attacks and Manchester bombing of recent years. In light of this, contingency plans are required for such eventualities. However, it is difficult to ensure that staff have been exposed to sufficient volumes of trauma to be competent and familiar with the management of these types of injuries. It is essential that innovative strategies are adopted to ensure that in the event of a major urban terror attack or other such disaster there are staff available who can provide surgical leadership. In peaceful countries with much less interpersonal conflict and penetrating trauma, such as Japan, trauma training is impeded by a lack of clinical material as well as by systematic factors. Training a trauma-competent military or civilian surgeon in such an environment is difficult. South Africa has a sufficient burden of trauma and a well-developed academic infrastructure to train trauma or military surgeons in a civilian setting. Each index case as identified from the military surgery literature has a sufficient volume in the PMTS. Based on the study, a 6-month rotation should be sufficient to provide exposure to almost all the major traumatic conditions. In addition, PMTS have sufficient academic support and capacity to ensure that such training is academically sound. Over the last three decades, numerous foreign-based surgeons have undertaken a clinical trauma elective in South Africa and have found this experience to be invaluable. Many of these surgeons have gone on to play major leadership roles in trauma care in their home countries. This study clarifies that an international trauma clinical elective in South Africa provides an unparalleled exposure to almost all forms of trauma in conjunction with a well-developed academic support program.

Recommendations:

As it is evident that the current training offered by a civilian major trauma center in South Africa offers sufficient clinical exposure and operative experience for international surgeons, developing a formal exchange program will be beneficial. This will provide a formal program that allows motivated international surgeons to access appropriate trauma training. This will be an adaptable program that can be customized to meet the training needs of individual surgeons. The number of external rotators at each time should be limited to prevent overcrowding. In addition, such a program should provide new opportunities to foster links with international centers of surgical excellence and lead to the development of reciprocal exchange programs where South Africa surgeons can benefit from the expertise that overseas centers offer in advanced laparoscopy and organ transplantation. Any such program must be mutually beneficial if it is to be fair and sustainable.

Appendix: Trauma Fellowship Survey

Demographics
Name
Age
Gender
Country of Origin
Country Practiced
Current Country of Practice
Primary Speciality
Primary Subspeciality
General Surgery Residency
Where did you completed your residency?
How many years was the residency training programme?
How often do you rotate through different services during your residency?
Did your programme have specific rotation in Trauma Surgery?
If so, how long was the rotation?
Was the rotation based in a trauma centre?
If so, was it a Level 1, 2 or 3 (ACS) centre?
Did your programme have specific rotation in Critical Care?
If so, how long was the rotation?
Post Residency Training
Is post residency training compulsory in your country?
Is trauma surgery recognised as a subspecialty in your country of practice?
Is formal trauma fellowship in order to practice as a trauma surgeon in your country?
Does your country offer formal trauma fellowship?
Perception prior to working in South Africa
Did you feel you trauma training and experience was adequate during:
Medical School?
Residency?
Post Residency ?
Did you consider your training adequate in managing:
Blunt trauma?
Penetrating Trauma?
SW?
GSW?
South African Training
Have you visited any South African Hospitals prior to taking up the position in SA?
Have you worked with any South African trained surgeon prior to applying for your position?
What was your perception of the quality of trauma training in SA prior to working here?
Is South African trauma fellowship recognised in your country?
Reason for Training in South Africa
Why did you choose SA as the destination for trauma training?
Why did you not choose other trauma training programme overseas?
Funding
How was your training funded?
SA Department of Health?
Sponsored by own government?
Sponsored by own hospital?
Self funded ?

Clinical Experience Prior to SA

How many of the following cases have you managed prior to working in SA?

Major Trauma Resuscitation

Gunshot wound

Stab Wound

Blast Injury

Road Traffic Accidents

How many of the following procedures have you performed or assisted prior to working in SA?

CVP Line

Chest Tubes

Intubation

Surgical Airway

Neck Exploration – SW

Neck Exploration – GSW

Neck Exploration – Blunt

Thoracotomy – SW

Thoracotomy – GSW

Thoracotomy – Blunt

Laparotomy – SW

Laparotomy – GSW

Laparotomy – Blunt

Damage Control Laparotomy

Peripheral Vascular Trauma – SW

Peripheral Vascular Trauma – GSW

Peripheral Vascular Trauma – Blunt

Clinical Experience during SA

How many of the following cases have you managed prior to working in SA?

Major Trauma Resuscitation

Gunshot wound

Stab Wound

Blast Injury

Road Traffic Accidents

How many of the following procedures have you performed or assisted in SA?

CVP Line

Chest Tubes

Intubation

Surgical Airway

Neck Exploration – SW

Neck Exploration – GSW

Neck Exploration – Blunt

Thoracotomy – SW

Thoracotomy – GSW

Thoracotomy – Blunt

Laparotomy – SW

Laparotomy – GSW

Laparotomy – Blunt

Damage Control Laparotomy

Peripheral Vascular Trauma – SW

Peripheral Vascular Trauma – GSW

Peripheral Vascular Trauma – Blunt

Career Progression

How long did you spend working in South Africa?

Did you consider your training in SA relevant?

Has your career progressed as a direct result of your time in SA?

Personal

Did you encounter any situation where your personal safety was at risk?

Appendix: BREC approval



01 August 2017

Dr H Uchino (216076538)
School Clinical Medicine
College of Health Sciences
hayakiu@gmail.com

Dear Dr Uchino

Protocol: Quantifying the clinical exposure needed to adequately prepare military surgeons for deployment to conflict and disaster zones
Degree: MMedSc
BREC Ref No: BE427/17

EXPEDITED APPROVAL

A sub-committee of the Biomedical Research Ethics Committee **has** considered and noted your application received on 07 July 2017.

The conditions have been met and the study is given **full ethics approval** and may begin as from 01 August 2017.

This approval is valid for one year from 01 August 2017. To ensure uninterrupted approval of this study beyond the approval expiry date, an application for recertification must be submitted to BREC on the appropriate BREC form 2-3 months before the expiry date.

Any amendments to this study, unless urgently required to ensure safety of participants, must be approved by BREC prior to implementation.

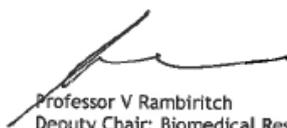
Your acceptance of this approval denotes your compliance with South African National Research Ethics Guidelines (2015), South African National Good Clinical Practice Guidelines (2006) (if applicable) and with UKZN BREC ethics requirements as contained in the UKZN BREC Terms of Reference and Standard Operating Procedures, all available at <http://research.ukzn.ac.za/Research-Ethics/Biomedical-Research-Ethics.aspx>.

BREC is registered with the South African National Health Research Ethics Council (REC-290408-009). BREC has US Office for Human Research Protections (OHRP) Federal-wide Assurance (FWA 678).

The sub-committee's decision will be **RATIFIED** by a full Committee at its next meeting taking place on 12 September 2017.

We wish you well with this study. We would appreciate receiving copies of all publications arising out of this study.

Yours sincerely



Professor V Rambiritch
Deputy Chair: Biomedical Research Ethics Committee

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