Beyond the Forensic Pathology Investigation: Improving Warfighter Survivability

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ABSTRACT

The Armed Forces Medical Examiner System (AFMES) conducts forensic pathology investigations in accordance with Title 10 U.S. Code 1471. Since 2004, the AFMES has incorporated advanced radiologic imaging, such as computed tomography, into its protocol. This incorporation has led to increased fidelity in depicting injuries, efficient localization of foreign bodies, and the ability to accurately document medical therapy – all of which enhance the forensic pathology investigation. As with most jurisdictions, information contained in the forensic pathology investigation is disseminated to family members and criminal investigating authorities. In addition, AFMES also disseminates information regarding the location of resuscitative devices to casualty care providers and trainers, collaborates with trauma physicians and medical providers in regards to evaluating injuries and treatment for the assessment of potential improvements in medical care and survivability, and provides information and subject matter expertise to investigative boards and other organizations that reconstruct fatal events. The overarching goal of these additional collaborations is to enhance the understanding of the nature of traumatic injuries, improve casualty care, and ultimately decrease morbidity while improving survivability. *Acad Forensic Pathol.* 2017 7(4): 591-603

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As per Journal Policies, ethical approval was not required for this manuscript

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INFORMATION

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INTRODUCTION

Within the Department of Defense (DOD), the Armed Forces Medical Examiner System (AFMES) headed by the Armed Forces Medical Examiner (AFME) was established in 1988 by DOD Directive 6010.16 (1). This DOD Directive gave the AFME the authority to conduct forensic pathology (medicolegal death) investigations on US Service Members who died on installations garrisoned by the Armed Forces that are under exclusive federal jurisdiction. The AFME's authority to conduct forensic pathology investigations on US Service Members who died outside exclusive federal jurisdiction, on installations that are under concurrent (both federal and local) jurisdiction, during training mishaps occurring off installations, and during contingency operations was limited. In addition, there was limited authority to conduct forensic pathology investigations on non-DOD US citizens who died on installations, regardless of jurisdiction, during training, or aircraft mishaps that involved DOD equipment. In order to remedy these limitations, Title 10 U.S. Code 1471 was enacted in 1999 (2). This Federal statute gives the AFME the authority to conduct forensic pathology investigations on any individual found dead or who dies on a garrisoned installation under exclusive federal jurisdiction, any US Service Member on active duty or inactive duty for training, recently retired US Service Members, and Civilian Dependents of US Service Members who are found dead or die outside of the US. In the case where the individual did not die on exclusive federal jurisdiction, the exercise of the authority by the AFME is subject to the exercise of the primary (local) jurisdiction. However, this does not limit the authority of the AFME to conduct an investigation and the jurisdiction can be released to the AFME or the AFME can conduct a secondary investigation. In addition, this statute provides a mechanism for the AFME to conduct forensic pathology investigations in support of authorized investigations by the DOD, Federal Bureau of Investigation, National Transportation Safety Board, or any other Federal agency with the authority to direct a forensic pathology investigation.

When combat operations commenced in response to the terrorist attacks of September 11, 2001 (Operation

Enduring Freedom) and against Iraq in 2003 (Operation Iraqi Freedom), the AFME made the decision to perform complete autopsy examinations on all Service Members deployed to support these operations (also known as contingency operations). Prior to this date, forensic pathology investigations included the scientific identification of the deceased but a complete autopsy to include internal examination and ancillary studies was not always performed. In 2004, the Defense Advance Research Project Agency (DARPA) collaborated with the AFMES and General Electric to install a computed tomography (CT) device within the AFMES autopsy facility to augment the radiologic imaging and determine the efficacy of CT in a forensic pathology investigations. It was quickly realized that CT imaging allowed for greater specification of skeletal injuries and precise location of foreign objects, such as projectiles, within the clothing and body (3-6). In addition, resuscitative medical therapy such as airway devices, intraosseous needles, and tourniquets were readily visualized (6). The forensic pathology investigation protocol at the AFMES for contingency operations and mishaps includes the following steps: investigation of circumstances surrounding the death; identification of the deceased by scientific means (e.g., fingerprint, dental and/or DNA comparison); radiologic imaging (e.g., fluoroscopy, digital radiographs and/or CT); digital photographs; external examination including documentation of the clothing, protective equipment and resuscitative medical therapy; internal examination; toxicology analyses; and histologic examination, as necessary. Based on this complete forensic pathology investigation, one can determine the decedent's identity, accurately describe the injuries and/or natural disease, determine the cause and manner of death, and prepare a report with these findings. As with other medicolegal jurisdictions, the results of these findings are provided to the families and criminal investigating agencies. In addition to these traditional avenues for dissemination of information, the AFMES also disseminates information regarding the location of resuscitative devices, collaborates with trauma physicians and medical providers in regards to evaluating injuries and treatment for the assessment of potential improvements in medical care and survivability, and provides information and subject matter expertise to

investigative boards and other organizations that reconstruct fatal events. The overarching goal of this additional dissemination of information is to enhance the understanding of the nature of traumatic injuries, improve casualty care, and ultimately decrease morbidity while improving warfighter survivability.

DISCUSSION

Feedback to the Field

All resuscitative devices, such as endotracheal tubes and intravascular lines, should be left in place after an individual has been declared deceased. These devices and all medical intervention, such as resuscitative thoracotomy, are commonly documented during the external examination and occasionally the internal examination. Radiologic imaging, especially CT, may allow for precise location of resuscitative devices on and within the body. In 2006, it was noted that in some deceased individuals, the angiocatheter needles placed for decompression of a possible pneumothorax did not enter the pleural space on CT and subsequent internal examination. It was hypothesized that the chest wall thickness of many individuals was greater than the 5 cm angiocatheter needle that was standard issue in each Service Member's first-aid kit. A retrospective study evaluating the chest wall thickness overlying the 2nd intercostal space on CT was conducted (**Image 1**). The results indicated that in approximately 50% of the individuals, a 5 cm angiocatheter needle would not enter the chest cavity and an 8 cm angiocatheter needle was needed (7). These findings led to a change in the length of the angiocatheter needle carried by each Service Member in their first-aid kit (8).

Although the results of the chest wall thickness study were published in a peer-reviewed journal with wide dissemination in the US Military medical community, there was delayed time in getting information to medical providers and medical trainers, especially those in a deployed setting. In order to rapidly disseminate observations of medical therapy, presence and placement, especially resuscitative therapy, the AFMES developed an electronic communication designated Feedback to the Field (FT2F). These communications

are case-based observational data that are unclassified, de-identified and unlinked to the occurrence, do not assess effectiveness of treatment or relation to outcome, and do not suggest or advise policy. They are rapidly communicated to the forward deployed medical providers and medical trainers. Those in receipt decide the value and how it is to be used. These communications have covered airway management devices, tourniquets for hemorrhage control, infusion devices, needle thoracotomy devices, and pelvic stabilization devices (9). For example, the location of an emergency tracheostomy can be readily visualized on CT. **Image 2** depicts a properly placed tracheostomy inferior to the thyroid cartilage and **Image 3** depicts an improperly placed tracheostomy superior to the thyroid cartilage. Similarly, sternal (**Image 4**), tibial (**Image 5**), and humeral (**Image 6**) intraosseous devices positions can easily be depicted. The communications can be based on a single case such as the improper use of an intraosseous needle in the sternum (**Image 7**) or an aggregate of observations of a particular therapy. The results from these communications have been used in reinforcing

Image 1: Computed tomography sagittal view of thorax at midclavicular line with horizontal and perpendicular chest wall thickness measurements at 2nd intercostal space.

training techniques and in guiding process improvement by the Committee on Tactical Combat Casualty Care with the goal of improving battlefield medicine and increasing warfighter survivability (10, 11).

With increased use of these resuscitative devices in multiple civilian municipalities, similar studies can be conducted by other medicolegal jurisdictions with the overall goal of improving the trauma care system. Information from these studies may be helpful to first responders and other emergency personnel that are using a new device or have a question regarding success of a particular technique. It must be noted that

device assessment at the time of examination by the forensic pathologist may not be accurate since devices can shift position during transport and the handling of bodies. Furthermore, the clinical effectiveness cannot be assessed due to the complex physiologic factors involved in injury and resuscitation. However, by providing this feedback with regard to anatomic position and physical characteristics, inferences can be made about the specific device or intervention. For example, in a study of 61 tibial intraosseous devices, 95% were successfully positioned in medullary bone (12), and in a study of 98 sternal intraosseous devices, 80% were successfully positioned (13).

Image 2: Computed tomography midline sagittal view of the neck depicting proper tracheostomy tube placement inferior to the thyroid cartilage (T). Note location of hyoid bone (H).

Image 3: Computed tomography midline sagittal view of the neck depicting improper tracheostomy tube placement (arrow) superior to the thyroid cartilage (T) and inferior to the hyoid bone (H).

Image 4: Computed tomography midline sagittal view of the sternum depicting tip of sternal intraosseous device properly placed within the manubrium (arrow).

Mortality Conferences

Although hospital-based autopsies have declined over the past decade, most hospitals still have morbidity and mortality conferences. In these conferences, there is communication between the treating physicians and the pathologist(s) that conducted the autopsy examination and correlations are made with the goal of decreasing morbidity and mortality. In most medicolegal jurisdictions, there is limited communication after the forensic pathology investigation has been completed between the forensic pathologist and treating physicians, especially the trauma physicians. Until 2009, there was no formal communication between the AFMES and deployed physicians that had treated service members who died or came to their facility deceased. In 2009, a biweekly conference was established that discussed the forensic pathology investigation findings with the deployed treating physicians and medical providers. Response from deployed medical providers to these biweekly conferences was overwhelmingly positive, as it informed them of the extent of injuries and helped with defining the possible mechanism of death, especially in polytrauma individuals exposed

to blast events. With the decrease in fatalities, these biweekly conferences evolved into a formal monthly conference between physicians at the DOD Joint Trauma System, physicians at AFMES, and deployed physicians and medical providers. These conferences discuss all individuals that die in contingency operations regardless of whether the individual received medical treatment or not. The emphasis is on the injuries received and any medical treatment observed. The goal of these conferences is two-fold: to identify any process improvements that can be made in combat casualty care and determine the survivability or potential survivability of the injuries sustained.

There have been several studies that have evaluated the injuries sustained, including the survivability of those injuries, during contingency operations in those who have died (14-18). Crucial to this evaluation is a complete forensic pathology investigation, including a complete autopsy with radiologic imaging, on all individuals and collaboration between the forensic pathologist and trauma physicians. Results from these and other studies have driven research and new techniques in combat casualty care. Examples are the

Image 5: Computed tomography axial view of the proximal legs depicting intraosseous device properly placed within the right tibia (arrow).

implementation of hemorrhage control devices such as junctional tourniquets and resuscitative endovascular balloon occlusion of the aorta (REBOA), wide use of intraosseous catheters, and universal use of tourniquets for extremity injuries (19). Many of these lessons learned have been integrated into the civilian literature and civilian trauma system. Excellent examples are the Stop the Bleed Campaign and the actions of first responders and nonmedical personnel immediately following the terrorist bombing during

the Boston Marathon. The early application of tourniquets immediately following the explosion has been credited with saving multiple lives (20). Furthermore, the National Academies of Sciences, Engineering and Medicine published a report titled “*A National Trauma Care System: Integrating Military and Civilian Trauma Systems to Achieve Zero Preventable Deaths after Injury*” in 2016 (21). Achievement of this lofty goal will require complete forensic pathology investigations, not just external examinations, of all indi-

Image 6: Computed tomography coronal maximal intensity projection of the left shoulder depicting properly placed intraosseous device within the humeral head (arrow).

Image 7: Computed tomography midline sagittal view of the sternum depicting incorrect use of an intraosseous device that perforates the sternum into the anterior mediastinum.

viduals who are injured and collaboration with trauma physicians and medical providers. Mortality conference will have to become commonplace in all medicolegal jurisdictions.

Investigative Boards, Joint Trauma Analysis, and Prevention of Injury in Combat

Each of the respective US Military Services has their own safety centers. The mission of these safety centers is to understand the causal nature of a mishap with the goal of mitigating or eliminating future injuries and/or death. When there is a mishap, an investigative board is established to accomplish these goals. Although composition of the board members may dif-

Image 8: Computed tomography coronal maximal intensity projection depicting multiple bilateral rib and transverse process fractures. Bilateral scapular fractures are also present.

fer depending on the Military Service and/or nature of the mishap, each of the boards has a medical member. This medical member is responsible for evaluating the human factors surrounding the mishap and interpreting the injuries sustained in the context of the mishap. These medical members usually have limited experience with traumatic injury and forensic pathology. As part of its mission, the AFMES provides subject matter expertise to these individuals even in mishaps that AFMES did not have primary jurisdiction and did not perform the forensic pathology investigation. Complete autopsy examinations and radiologic imaging, preferably CT, as well as comprehensive toxicology analyses, are needed to accurately report all injuries sustained and correlate them to the mishap. For example, fractures of the transverse and spinous process of the lumbar vertebrae not easily visualized on traditional radiographs or internal examination (**Image 8**) are consistent with a force being transmitted in the axial direction. In conjunction with information about the mishap, this may help determine when and what type of forces were transmitted to the body. In addition to evaluating single events, the safety centers can also aggregate data. This aggregation of data is similar to the process in which some medicolegal jurisdictions provide data to crash injury databases such as the Crash Injury Research Network (CIREN). Like the safety centers, the goal of these networks is to understand what injuries are occurring, how they are occurring, and what can be done to either prevent or mitigate these injuries. Accurate and complete injury data gathered from actual events will increase the fidelity of and refine the modeling systems that these networks have developed and are developing with the goal of improved automobile design and decreased morbidity and mortality.

The AFMES performs a complete forensic pathology investigation on all US Service Members that die during contingency operations such as Operation Enduring Freedom, Operation Iraqi Freedom, and Operation New Dawn. Since its inception in 2006, the AFMES has been part of the DOD Joint Trauma Analysis and Prevention of Injury in Combat (JTAPIC) program (22). This collaborative partnership brings together DOD medical, intelligence, and material communi-

ties. The role of AFMES in JTAPIC is to provide injury descriptions and injury analysis for all contingency operation deaths of US Service Members, facilitate the transfer of personal protective equipment from deceased US Service Members to appropriate agencies, and facilitate the transfer of evidence, such as ballistic projectiles, to the appropriate agencies. Using the expertise of all of the partner communities, JTAPIC can evaluate an event or multiple events, compare them to live-fire testing or modeling, and provide analyses that can be used to improve tactics, techniques, and procedures (TTP); personal protective equipment such as helmets and body armor; and vehicle design such as the implementation of V-shaped hulls.

CONCLUSION

Since September 11, 2001, the AFMES has conducted complete forensic pathology investigations on over 5000 US Service Members who have died in support of contingency operations and during training mishaps. In addition to providing the findings of these investigations to family members and commanders, the findings are also disseminated to combat casualty care providers and trainers, trauma physicians and deployed medical providers, and investigative boards and organizations that evaluate combat and fatal events. This dissemination of information has supported the improvement of combat casualty care and led to changes in TTP, personal protective equipment, and vehicle design that have increased warfighter survivability.

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