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ON THE COVER:
The trauma care unit at Truman Medical Center turning a patient during a recent earthquake drill. (Photo courtesy Truman Medical Center)
Fifty Years of Trauma
By Charles W. Van Way, III, MD, Editor, Kansas City Medicine

VIOLENCE IS AS AMERICAN AS CHERRY PIE.
~ H. Rap Brown, ca 1965

Long ago, in a city far away, I was introduced to trauma. It was the 1960s, my first rotation as a surgical intern. A man came in, beaten up. (Today, we call it “interpersonal blunt trauma”) Big scalp laceration. Slightly depressed skull fracture. Drunk, but awake and alert. I called the neurosurgeon, who said, “Now, Dr. Van Way, you do know how to elevate a skull fragment, don’t you?” In the day, that was attending-speak for, “it’s the middle of the night, boy, and I’m not going to come in.” In fact, I did know how to do it. A couple of hours later, I’d actually done it. Once. Nobody turned a hair, and the patient did just fine. It was a simpler time.

Even though I don’t really think of myself as a trauma surgeon, I’ve done my share of trauma, and a bit more. I’ve been chief of surgery in two different trauma hospitals (Denver General Hospital and Truman Medical Center). I’ve headed up a shock-trauma research center. Still do, for that matter. I’ve had research grants. Co-edited a book on trauma. Since the 1960s, I’ve been a sometime participant and an always-interested observer of the trauma scene. It has been a very active 50 years in the world of trauma care. So … with that lead-in, let me reflect on that last half-century.

1950: CIVILIAN TRAUMA SYSTEM OUT OF DATE
We emerged from a decade of war into the mid-1950s, with a large amount of military experience in trauma. But the civilian trauma system was decades out of date. This changed, although it wasn’t particularly easy, nor was it painless. Understand that experienced trauma surgeons. When they came back, they were appalled at the poor quality of civilian trauma care. And because most of them were young, they had the energy and the drive to make things better. Dr. Kendall McNabney, for example, came back from the Vietnam War, and began one of the nation’s first emergency medicine programs at Truman Medical Center. The American College of Surgeons, and many other professional organizations, worked hard to improve things. Advanced Trauma Life Support (ATLS) dates to the 1970s. As does accreditation of civilian trauma systems. And emergency medical technician training. After a certain amount of turmoil (well, a whole lot of turmoil), the medical system responded by increasing and expanding emergency departments, intensive care units and emergency medical services. By the 1980s the system had changed. Besides the growing specialty of emergency medicine, trauma surgery had become a sub-specialty of general surgery. Hospitals poured resources into space, equipment and staffing. Our present-day trauma system is the beneficiary of these changes.

But an odd thing happened. The incidence of trauma began to drop off. Most importantly, deaths from MVAs fell by almost two-thirds. These were the largest cause of trauma death, and this dramatic drop was very significant. Much was due to better safety features (seat belts, air bags and other

From World War II through Korea and most particularly Vietnam, surgeons went off to war and returned as experienced trauma surgeons. When they came back, they were appalled at the poor quality of civilian trauma care.

1950 to 1980 was a difficult time in many ways. Trauma was rising. Death rates rose for motor vehicle accidents (MVAs), homicides and suicides were at century’s high (Figure 1). The health system was severely challenged.

From World War II through Korea and most particularly Vietnam, surgeons went off to war, and returned as experienced trauma surgeons. When they came back, they were appalled at the poor quality of civilian trauma care. And because most of them were young, they had the energy and the drive to make things better. Dr. Kendall McNabney, for example, came back from the Vietnam War, and began one of the nation’s first emergency medicine programs at Truman Medical Center. The American College of Surgeons, and many other professional organizations, worked hard to improve things. Advanced Trauma Life Support (ATLS) dates to the 1970s. As does accreditation of civilian trauma systems. And emergency medical technician training. After a certain amount of turmoil (well, a whole lot of turmoil), the medical system responded by increasing and expanding emergency departments, intensive care units and emergency medical services. By the 1980s the system had changed. Besides the growing specialty of emergency medicine, trauma surgery had become a sub-specialty of general surgery. Hospitals poured resources into space, equipment and staffing. Our present-day trauma system is the beneficiary of these changes.

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TRIUMA (continued)

In the 1950s, drunk driving was far more tolerated than it is today. It was never actually acceptable, but it was far more tolerated. The overall numbers and incidence of motor vehicle crashes have also fallen, not only the deaths resulting from them.

Interpersonal violence also changed. Homicide deaths initially rose, but then fell by half. The drop in homicide rates was paralleled by a decrease in all violent crimes. Firearm-related deaths fell by a third. They decreased with the drop in violent crime overall. While this data represents the population as a whole, there is still great public concern over the high rate of urban gun violence, and the shock of mass shooting incidents.

The media and politicians wring their collective hands incessantly, and it seems that things are worse than ever. But the figures say otherwise. On the whole, have we in fact become safer? In a word, yes. We are safer, both because the incidence of trauma has dropped, and because we have a much better trauma system. Granted, it is not fashionable to point these things out, and we should remain concerned about gun violence where it is rampant.

Trauma system improvements have been truly amazing. I believe it was at that city hospital that I learned to look in the back of the ambulance first. Because, it was in the back of the ambulance that we found the worst-injured patients. In those days, ambulances were likely to be doing day duty as hearses, and their drivers were virtually untrained. Today? The ambulance is staffed by trained emergency medical technicians. Now, the sickest patient comes out first. And all patients are better cared for even before they arrive at the emergency department.

CHALLENGES MOVING FORWARD

But motor vehicle crashes, interpersonal violence and other causes of injury are still with us. A lowered incidence is all very well, but the total number of victims remains large. We are certainly better able to take care of those hurt in an auto crash, or shot in a barroom fight. But a look at Figure 1 confirms that the improvements of the past 40 years are tapering off. Yes, it’s been a good 50 years. But no, the work has not yet finished.

What is trauma? To most of us, trauma connotes accidents or intentional violence. To the trauma surgeon, an injury is a problem to be solved. We’ve become really skilled at that. But looking at society as a whole, trauma is a disease. And more than that, it’s a chronic and recurring disease. We’ve done a pretty good job on trauma from motor vehicles. As noted above, a lot of safety features are now built into vehicles. People now pay some attention to driving safely (I know, not on your morning commute). But when I was young, there were no designated drivers. How did we survive? Well, some didn’t. Most of us knew someone who was killed in an auto crash. That’s much less true today.

Consider homicide. Among men 20-25 years old, the incidence of homicide is four times that of the general population. Some subgroups in the population have considerably higher rates than that. It’s a disease of poverty, we say. But that’s an association, not a cause. We could equally say that a tendency to violence is one of the causes of poverty. Perhaps so. All of this is just playing with words. The incidence of homicide and other sorts of violent crime has indeed decreased. What did we do right? Ask the experts, and you’ll get as many theories as you have experts. The truth is, we don’t really know. What would we do if the rates start to go up again? If we don’t know what worked before, we’re going to have a hard time figuring out what
So, 50 years of trauma. We can, and should, compliment each other for all of the great accomplishments in the care of injured people. And we can be very happy that the incidence of trauma has dropped. We still take care of too many victims. But at least, the problem isn’t getting worse. Yet, we have to recognize that we have far to go. Our country still has a homicide rate far in excess of most of the “civilized” countries of Western Europe. Some 2,500 people die each month from motor vehicle crashes. Part of the solution for these problems will come from us, or from the health care system. But health care is not the whole answer. As physicians, we are expected to be leaders in this effort. And so we should be.

Charles W. Van Way, III, MD, is editor of Kansas City Medicine and is emeritus professor of surgery at the University of Missouri-Kansas City. He is also director of the UMKC Shock Trauma Research Center. He can be reached at cvanway@kc.rr.com.

REFERENCES
Pediatrician Gary Pettett, MD, FAAP, oversaw infant care and trained physicians for more than 40 years across two careers spanning service with the U.S. Army, and then in leadership with Children’s Mercy Hospital, Truman Medical Center and the University of Missouri-Kansas City. He also led the Kansas City Medical Society and the Missouri State Medical Association.

KCMS honored Dr. Pettett for his contributions by presenting him with the Lifetime Achievement Award at the 2016 Annual Meeting on Sept. 14. Now retired, Dr. Pettett and his wife, Virginia, divide their time between Boise, Ida., and Tucson, Ariz.

NEWBORN CARE FOR MILITARY FAMILIES

A native of Lincoln, Neb., Dr. Pettett became interested in medicine while studying in the College of Pharmacy as an undergraduate at the University of Nebraska. He entered medical school at Indiana University in 1967 when the Vietnam War was at its peak and the draft still in force. As an alternative to being drafted, Dr. Pettett elected to join an Army Reserve program for medical students during his third and fourth years. After graduation, this program sent him to the former Fitzsimons Army Medical Center in Aurora, Colo., for internship and residency.

While at Fitzsimons, Dr. Pettett and a colleague developed a program for transporting seriously ill newborns from community hospitals around the state to Denver for specialized care.

“This opened the avenue for infants born in community hospitals to have access to the treatments we could provide in the metropolitan area,” he said. “Medical transport was not as established then. We gathered equipment and staff from hospital nurseries, and put them on helicopters or fixed-wing aircraft. It was far from fancy.”

Twenty years later, when he was managing the transport team at Children’s Mercy, things were much different. “By then, quite a bit of equipment had become commercially available, specifically designed for altitude and transport,” he said.

Dr. Pettett’s military service took him on four additional tours of duty. He served as chief of newborn medicine, directed neonatal intensive care units, and trained Army physicians at stations in San Francisco, Honolulu and Tacoma, Wash. His final and longest station was eight years at Walter Reed Army Medical Center, where he was an associate professor and director of fellowship training at the Uniformed Services University of Health Sciences.

During his Army career, Dr. Pettett and his wife, Virginia, raised their two children, Lisa and Scott. “The Army was a great experience. The kids got to be very comfortable moving around and taking on new situations,” Dr. Pettett said. But by 1993, the children were grown, and both Dr. and Mrs. Pettett had aging parents back in Nebraska. It was time to head back to the Midwest. He retired from the Army at the rank of colonel.

SETTLING IN KANSAS CITY

With the help of a former colleague, Howard Kilbride, MD, of Children’s Mercy Hospital and the UMKC School of Medicine, Dr. Pettett secured a faculty appointment. He also became director of the newborn transport service with Children’s Mercy, and director of nurseries for Truman Medical Center.

Through the 2000s, he held various positions at the medical school including associate dean for academic affairs,
and course director of the history of medicine course. From 2008 to 2012, he was medical director of the E. Grey Dimond Program in International Medicine in which medical students can elect to spend time in foreign countries to learn about the medical issues and challenges unique to other cultures. At Children’s Mercy, he was director of the Office for Research Integrity (Institutional Review Board) from 2004 to 2010. In addition to his clinical activities, Dr. Pettett was appointed as a Fellow at the Center for Practical Bioethics in Kansas City. Now, in retirement, he is an Emeritus Professor at the UMKC School of Medicine.

One of his longtime colleagues was KCMS board member Charles W. Van Way, III, MD. They served together both at UMKC and in the U.S. Army Reserve. He said, “Dr. Pettett was a well-respected teacher of medical students. The students who rotated through the neonatal unit were uniformly impressed. At Children’s Mercy, he was in charge of the biggest and best nursery in the Kansas City area.”

**Kansas City Medicine 2016 Annual Meeting Awards**

Dr. Pettett is respected for his outstanding intelligence, integrity and mastery of medicine. He is an empathetic physician who has been a role model for many. He’s done a superb job in everything he’s accomplished.”

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**Guiding Principles**

Through his career, the doctor-patient relationship was of utmost importance, especially with parents facing difficult circumstances with their infants. Dr. Pettett said, “My job was to share as much information with families on a straightforward basis, so they could make informed decisions that best suit their lifestyles and goals. The tendency today is to treat patients with algorithms. Having guidelines may be helpful, but when you take the patient-physician discussion out of the equation, you’re just making cookies in the kitchen.”

Dr. Pettett was widely published through his career, as author or co-author of 13 book chapters, 20 articles in refereed journals and 35 abstracts. His works appeared in such journals as Pediatrics, Radiology and American Journal of Obstetrics & Gynecology.

By 2012, Dr. and Mrs. Pettett determined that they had many more things they wanted to do with their lives, so they retired, she from her work as a career counselor. One step was to establish a home in Boise near two of their grandchildren. Next year, they are planning a trip to their ancestral homelands in England and East Prussia. “Virginia has pursued genealogy (continued on next page)
GARY PETTETT, MD (continued)

for more than 40 years, and has traced our families back to the 16th century,” he said.

Dr. Hagan concluded, “Dr. Pettett is respected for his outstanding intelligence, integrity and mastery of medicine. He is an empathetic physician who has been a role model for many. He’s done a superb job in everything he’s accomplished.”

Dr. Van Way added, “With everything he was involved in, he was uniformly positive in his contributions and profound in his thinking. He has had a long record of service to our medical society, Children’s Mercy Hospital, UMKC and our country.”

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For the past 10 years, the vegetable garden at Cross-Lines Community Outreach, Inc. has been an oasis of fresh, healthy produce for low-income residents of the Armourdale neighborhood in Kansas City, Kan. Without a grocery store or a place to buy healthy food at a reasonable price, Armourdale is considered a “food desert.”

Spearheading the creation of the garden was Glenn R. Hodges, MD, who volunteers with Cross-Lines and also is a Master Gardener and award-winning rose grower. Dr. Hodges was recognized for this service with the 2016 KCMS Community Service Award presented at the Annual Meeting.

Dr. Hodges began pursuing gardening more actively after he retired in 1998 from his career as chief of staff with the Veterans Administration Medical Center and on the faculty of The University of Kansas School of Medicine. He obtained Master Gardener certification and got involved in the rose societies in Kansas City and Johnson County. He also continued volunteer service with Cross-Lines, which he had already been doing through his church. In 2006, he was recruited to the Cross-Lines board.

“That fall, two staff members and I decided we were going to have a garden,” Dr. Hodges said. “It was a vacant lot, just under a quarter acre, located in between two Cross-Lines buildings. In spring 2007, we had it plowed and started growing vegetables.”

Today, the garden harvests approximately 4,000 pounds of produce annually and has surpassed 40,000 pounds over its 10-year history. The produce is distributed to area residents free through Cross-Lines’ food pantry, and utilized in the agency’s kitchen where it serves meals to needy residents. Some produce also is sold at low cost to those who don’t qualify for free food. Cross-Lines assists individuals and families in poverty to meet essential needs for food, clothing and shelter.

Dr. Hodges continues to work two mornings a week in the Cross-Lines garden. He also recruits other volunteers and secures funds for seeds, fertilizer and transplants.

“We were able to transform a little patch of ground that wasn’t being used. Now, it helps feed hungry people in southeastern Wyandotte County who would not otherwise have access to fresh produce,” he said.

In 2013, the garden was expanded with an orchard of 15 apple and pear trees. Cross-Lines also offers raised-bed gardens to area residents that they can maintain on their own.

Dr. Hodges was chief of staff at the Veterans Administration Medical Center in Kansas City from 1987 to 1996 and was chief of the section of infectious diseases there from 1974 to 1990. He was on the faculty of The University of Kansas School of Medicine from 1974 to 2004. He was chief of the section of infectious disease at the Veterans Administration Medical Center in Leavenworth, Kan. from 1996 to 2001.

He said, “I feel compelled to give back to the community. It’s a sign of appreciation for what’s been given to me.”
Bridget McCandless, MD, MBA, FACP, has dedicated her career to improving the health of vulnerable populations and promoting policies that advance public health. For 14 years, she was the founder and head of a free clinic serving low-income families in Independence, and for the past three she has overseen grantmaking and public health advocacy as president and CEO of the Health Care Foundation of Greater Kansas City. She also has advocated for public health and vulnerable populations as a member and 2011 president of the Kansas City Medical Society.

For her service, KCMS is recognizing her with the 2016 Patient and Community Advocate Award, set to be presented at the 2016 Annual Meeting.

Dr. McCandless grew up in a culture of service. Her father, Don McCandless, Ph.D., professor emeritus of pharmacology at the Kansas City University of Medicine and Biosciences, would take her on weekly visits to a Kansas City jail where he served as chaplain. The family also volunteered at the Hope House domestic violence shelter in Independence.

“I was raised in a household where public service was expected. The adage ‘to him who much is given, much is expected’ was one critical to my upbringing,” she said.

Interested in medicine from a young age, Dr. McCandless obtained her undergraduate and medical degrees from the University of Missouri-Columbia. She completed her residency in internal medicine at the University of Virginia. In 2007, she earned an MBA in health care leadership from Rockhurst University.

After several years in private practice, she founded the Jackson County Free Health Clinic (later Shared Care Free Clinic) in Independence in 2000. The clinic served some 2,500 patients with chronic medical illnesses. She was supported by some 80 volunteers from a full range of health professions.

Serving patients at the clinic was most rewarding. She said, “People with social complexity are capable of the greatest health improvement when given the opportunity. I believe passionately that people will rise to their expectations. They never disappoint.”

Dr. McCandless also served five years as a founding board member of the Health Care Foundation of Greater Kansas City from 2003-2008, where as member and chair of the program and grants committee she was instrumental in the development of HCF’s guiding principles, funding focus areas and grant review process. The foundation was created in 2002 as a condition of the purchase of the nonprofit health care provider Health Midwest by the Hospital Corporation of America.

In September 2013, she was appointed president and CEO following the retirement of the founding CEO Steve Roling. HCF currently provides nearly $20 million annually in grants to programs in the greater Kansas City area that support care for uninsured, underinsured and other vulnerable populations; help deliver mental health care; and promote public health measures such as tobacco cessation and healthy communities.

She also carries out advocacy as a member of the HealthyKC Initiative of the Kansas City Chamber of Commerce, the Missouri Medicaid Oversight Committee, and the Health and Public Policy Committee of the American College of Physicians.

“The work I do now is a little less individual but rather is concentrated at the systems and policy level. It is a different kind of reward but also can be life changing for a community,” she said.

About receiving the Patient and Community Advocate Award, Dr. McCandless said, “It has been the privilege of my life to be a physician. The sacred trust between patients and physicians is never to be underestimated. I exist in a camaraderie of other physicians who do this hard work every day and it makes me so proud to be their colleague.”
Casey Willimann, MD, has made an impact in her short career. She is a board-certified pediatrician and internist and has been with Liberty Clinic since February 2014. She also is medical director of pediatrics at Liberty Hospital. Previously, she was an assistant professor at the University of Missouri-Kansas City School of Medicine, and a staff physician at Children’s Mercy Hospital and Truman Medical Center.

Dr. Willimann’s involvement with KCMS began in 2014 when she was appointed as Liberty Hospital’s representative on the KCMS board of directors. This year, she stepped forward to become co-chair of the Vaccination Task Force of KCMS and the WyJo Medical Society, where her commitment and leadership skills have become evident.

“As part of my job as a pediatrician, vaccines are something that I feel passionate about,” Dr. Willimann said. “When the idea of the task force was brought forward to the board, it was something that I felt moved to participate in. I volunteered to serve on the task force and ultimately became co-chair.”

With the task force, she has helped organize and present orientations on the vaccination program for practices and staff around the area. She has encouraged other physicians to talk directly to patients about the need to receive the HPV vaccine.

Service with the Vaccination Task Force and KCMS has been most rewarding for her. “This allows me to help so many more people than I could reach with my clinical practice. I know that I can help patients throughout the area by partnering with local physicians,” Dr. Willimann said.

Dr. Willimann is a graduate of the UMKC School of Medicine. She completed her internship in pediatrics and internal medicine at Saint Louis University, and her residency at UMKC.

About the award, she said, “The Medical Society has a long history of members who are incredible physicians and people. I’m humbled that they’ve chosen me to receive this award. I look forward to continuing to work together for a long time to come.”

KCU Student Receives Award for Outstanding Research

Kansas City University of Medicine and Biosciences (KCU) student Nicolina Smith was selected from among 143 entrants to receive the American Association of Clinical Anatomists’ (AACA) Sandy C. Marks Jr. Student Poster Presentation Award for outstanding research and study, and clarity of presentation. The award was given during AACA’s annual conference June 13-17.

Smith’s study was entitled, “Using Anatomical Landmarks to Avoid Phrenic Nerve Injury During Atrial Ablation Procedures.” Using 30 cadaveric specimens, Smith was able to take measurements of the location of the phrenic nerve in relation to the right superior pulmonary vein antrum, as well as the lateral border of the sixth thoracic vertebrae (T6). The research concluded that using T6 as a landmark, which can be viewed under fluoroscopy during the procedure, a physician can now make an approximate map to locate where the phrenic nerve lies.
Join in the HPV Vaccination Outreach Effort

The Kansas City Medical Society and the Wyandotte-Johnson County Medical Society remind area physicians to support the campaign underway to immunize preteens and teens against Human papillomavirus (HPV).

The KCMS-WyJo Vaccination Task Force has been holding education presentations throughout the area, and asking practices to identify champions who will promote HPV vaccination within their groups.

More than 26,000 people across the United States are affected by HPV-caused cancers each year, and Kansas and Missouri rank among the lowest nationally in HPV immunization rates. As of 2014, only 24.8% of girls in Kansas and 28.3% in Missouri had completed all three doses of the HPV vaccination series, according to the Centers for Disease Control.

To help increase immunization rates, the Vaccination Task Force recommends these talking points with patients:

Bundled language: “Your child is due for vaccinations today to protect against meningitis, HPV cancers, and pertussis. We’ll give those shots at the end of the visit.”

Why is this needed: “HPV vaccine is very important because it prevents cancer. I want your child to be protected against cancer, so I’m recommending we start the first dose today.”

Why now? “HPV vaccination provides the best protection when given at age 11 or 12, which is why I recommend starting the HPV vaccine series today.”

For more information, visit https://kcmedicine.org/vaccination/.

Virtual Doctor Visits Available Through Saint Luke’s Mobile App

Saint Luke’s Health System now is making available non-emergency visits with health care providers online and through smart phones via a new mobile application, Saint Luke’s 24/7.

Users can consult virtually with U.S. board-certified medical professionals over the telephone, or through secure video on a computer, smart phone or other mobile device, 24 hours a day. They can discuss such conditions as cold and flu, asthma, bronchitis, acne, allergies, fever, headache and sore throat, insect bites, diarrhea and nausea, and infections. The app is powered by MDLIVE, a national telehealth company.

After downloading the app and registering family members, users choose from among available providers, share the reason for the visit, and a brief health history with pre-existing conditions. Within approximately 15 minutes, users will be connected via telephone or real-time video with a provider, who will diagnose, recommend treatment and prescribe medicine in real time. Saint Luke’s physicians and nurse practitioners will provide this service, supported by MDLIVE’s physician network. The Saint Luke’s and MDLIVE providers consist of board-certified family medicine, internal medicine, emergency medicine and pediatrics practitioners.

The virtual visit experience is similar to a video chat, allowing patient and provider to ask questions, upload photos and video to assist with diagnosis, and discuss treatment options. Children as young as 18 months may be seen through the app. The cost per visit will vary, depending on a patient’s insurance plan, but typical cost will be $49 per visit.

Performance measures have been used to evaluate clinical performance by an individual or a group of individuals in health care for a very long time. In 1863, Florence Nightingale’s highly analytic essays, “Notes on Hospitals”1 changed forever how hospital care was performed by exposing the vast differences in outcomes between hospitals and linking them to the care practices at the time.

In the United States, between 1911-1917, a surgeon at the Massachusetts General Hospital (MGH), Ernest Armory Codman, performed an extraordinary service to American medicine by measuring, managing and reporting surgical outcomes.2 Unfortunately for Dr. Codman, his insistence on total transparency of all of the surgical outcomes resulted in a predictable response from his outraged (and embarrassed) surgical colleagues at the MGH, which, again proving the adage that “no good deed goes unpunished,” led to his appointment at the MGH being terminated. It was not Dr. Codman’s fate to be richly rewarded by his colleagues for his insights, but instead left to history to place his name among the most important positive influences on the practice of surgery in the United States. He ultimately became one of the physicians most responsible for the formation of the American College of Surgeons and the Joint Commission.3

Professor James Reason, one of the leading experts on human factors in the development of medical errors, considers delivering health care as one of the most error-producing activities on the face of the planet.4 The enormous complexity of health care and the need to make lifesaving decisions, often with only limited information, adds to the likelihood of errors that may cause injury to the patients.

The current emphasis in the U.S. appears to devalue quality improvement measures that are not linked either to accountability measures or some variation on pay-for-performance.

Most experts agree that current health care, as practiced worldwide, is often suboptimal. Medical errors are too common, patient safety is not assured, and the quality of health care is very uneven. As a result, there have been many efforts, including one by the Institute of Medicine in the United States, that have focused on improving the quality of health care and improving important clinical outcomes.5,6

ORIGINATED FOR GROUP LEARNING AND QUALITY IMPROVEMENT

Many physicians would tend to place the onset of the sustained efforts to introduce performance measurement into clinical practice as a relatively recent occurrence. They would probably be surprised that the model most often cited for evaluating the quality of care is the Donabedian Model, published in July 1966, which continues to be the organizing framework around nearly all the current efforts to improve health care by performance measurement.7,8

Arvedis Donabedian was a non-practicing physician, an immigrant to the United States, who spent most of his career at the University of Michigan. He was passionate about his efforts to help improve quality of care. His proposal was very simple: Measurement of performance was essential to improvement, and he proposed a triad of:

• **Structural Measures**: The context in which care is delivered, as for example, the equipment and staffing of an ICU;
• **Processes of Care Measures**: The transactions between patients and providers throughout the delivery process, such as whether a checklist was used before the surgical procedure to make sure all the essential processes had been done preoperatively;

(continued on next page)
PERFORMANCE MEASURES (cont’d)

• Outcome Measures: The effects of health care on the health status of patients and populations, as for example, what percentage of patients developed a hip fracture in the two years after therapy was started?

Performance measure development, which is evidence based when developed along the lines of the Donabedian Model, may be used in quality improvement to provide real-time feedback so the clinical team becomes a self-learning entity. In such a system, the performance measures are often used repetitively with the same providers and for the most part, risk adjustment is usually not required.

This model, also originally proposed by Donabedian and supported by many experts today, has the strength that when used in an iterative fashion and utilizing sound clinically relevant measures, can lead to very large improvements in quality of care. A model of this type was used by the pediatric gastroenterologists nationwide to greatly improve initial remission rates for inflammatory bowel disease in the pediatric population. The sharing of best practices, benchmarking and group learning were key to this successful effort. It was voluntary, physician-led, and not associated with any pay-for-performance metrics.

Although there are a number of other outstanding examples of equally successful physician-led voluntary efforts, the current emphasis in the U.S. appears to devalue quality improvement measures that are not linked either to accountability measures or some variation on pay-for-performance. A simple way of looking at so-called accountability measures is as a “snapshot in time,” that is, the performance at the moment the data was collected. Risk adjustment is usually necessary to fairly and scientifically compare outcomes, but although there is an excellent scientific literature to support risk adjustment, it is seldom used by payers. Organizations such as the National Quality Forum and others have been ardent advocates of accountability measures, usually without risk adjustment, and often devalue.

Perhaps the simplest way of thinking of a performance measure that is used primarily or exclusively for quality improvement is as merely a more formal way of checking your own work.

Public reporting is another current use of performance measures that is widely admired by both the public and many policymakers. It is often based on the notion that patients will avidly absorb the information and make decisions as to where to get their care accordingly. There is, of course, abundant evidence that most patients do nothing of the sort. Also, public reporting is often supported by those who believe that medical errors are only done by the “bad apples” in health care and by identifying those publically, both payers and the public will respond accordingly. Unfortunately, such beliefs are not substantiated in the medical error literature. A poorly-functioning health care system breeds errors, and replacing the person apparently responsible for the error will often not lower the frequency of errors. As for example, if similar-appearing vials containing very different drugs are stored in the same location, it will be more likely that the wrong drug will be given to the patient, as many people in that setting will make the same mistake.

Public reporting frequently leads to perverse incentives and results in unexpected outcomes. A statewide example of this was found in New York when it began public reporting. To the surprise of the health care planners, when the mortality statistics on cardiovascular surgery were widely shared, patients with a high risk for cardiovascular surgery often found they had decreased access to an appropriate, but higher risk, surgery in New York, and either did not get the needed surgery or had to go to another state for the surgery.

MEASUREMENT ELEMENTS IN MACRA

Performance measure development is complex, and since it is a central part of the new payment system that MA-
CRA establishes to replace the SGR, it is important to know something about the actual way in which measures are constructed. MACRA identifies five quality domains for measures developed under the Measure Development Plan (MDP) which can be used for the Merit Based Incentive Payment System (MIPS) or alternate payment models (APM).

These domains are:
• Clinical care
• Safety
• Care coordination
• Patient and caregiver experience
• Population health and prevention

The high priorities in measure development include:
• Patient safety measures (highest)
  ◦ Medication errors
  ◦ Complications from procedures
  ◦ All-cause harm in outpatient or ambulatory settings
• Outcome measure including patient reported outcome measures (PROM)
  ◦ Risk stratification is key for a valid and fair measure.

The MACRA law is very prescriptive, but reasonable with respect to how the measures need to be constructed in order to be approved for use. Most of the measures will be based on clinical practice guidelines from a specialty society, the NIH or CDC. All measures must have high levels of evidence in support and have been accepted by the National Guidelines Clearinghouse (NGC). Although these are the preferred sources, other sources may be considered, as for example, clinical review articles, treatment protocols and algorithms, but for these the bar is much higher, and additional “higher priority” elements may also be required. In theory, a qualifying QI initiative could possibly be used as the evidentiary base, but this is rarely done. However, in all cases, funding sources of guidelines should be disclosed and the date of development noted. It is far too common to see specialty or other source guidelines which are funded by a pharmaceutical company to have a distorted emphasis on their product.

The work group itself that creates the measures is also an item of importance, not just for MACRA, but for other reasons as well. As a veteran of many multi-specialty work groups over the years, while working with the AMA-convened Physician Consortium for Performance Improvement (PCPI), the organization which helped develop most of the measures used by CMS, it is clear that a balanced work group is best, the broader the representation the better. Multidisciplinary and multispecialty groups were key. Our best measure sets usually included outstanding specialists and primary care physicians, as well as methodologists and consumer (patient) input. The process invariably included public comments, which were often most illuminating and often led to substantial changes in the structure of the measures.

The measures themselves are structured as follows:
• Measure description
• Numerator statement
• Denominator statement
• Exclusions
• Exceptions
• Supporting guidelines

An example of the details of the structure of a measure is shown in Table 1.

Measure exceptions are used to remove patients from the denominator of a performance measure when a patient does not receive a therapy or service, and that the therapy would not be appropriate due to specific reasons for which the patient would otherwise meet the denominator criteria. Exceptions are not absolute and are based on clinical judgement, individual patient characteristics or patient preferences. Some examples of medical reasons for a measure exemption include contraindications, tests which were already performed, patient intolerance, co-morbidities, or allergies or side effects such as hypotension or muscle

Table 1. Example of a Measure

<table>
<thead>
<tr>
<th>ELEMENT</th>
<th>EXAMPLE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Measure Description</td>
<td>Screening for diabetic nephropathy</td>
</tr>
<tr>
<td>Numerator Statement</td>
<td>Patients for whom a serum creatinine with an eGFR and quantitative urinary albumin was obtained in the last 12 months</td>
</tr>
<tr>
<td>Denominator Statement</td>
<td>All patients with diabetes between the ages of 18-75</td>
</tr>
<tr>
<td>Exclusions</td>
<td>Patients who are pregnant</td>
</tr>
</tbody>
</table>
| Exceptions | Documentation of:  
  + A medical reason why a urinary albumin was not obtained prior use of ARB/ACE during time period  
  + Patient reason why a urinary albumin was not obtained, patient declined |
| Supporting Guidelines | American Diabetes Association Standards of Care (updated annually) |

(continued on next page)
PERFORMANCE MEASURES (cont’d)
breakdown. Some examples of patient reasons for a measure exemption include the patient refusing or declining, the patient’s functional limitations, access or insurance issues, social reasons, cost, religious preferences, or other personal reasons which would make meeting the criteria unacceptable to the patient.

Measure exclusions arise when patients who are included in the initial patient or eligible population do not meet the denominator criteria specific to the intervention required by the numerator. Exclusions are absolute, apply to all patients, and are not part of the clinical judgement within a measure. For example, if the denominator is for heart failure and left ventricular systolic dysfunction, and the numerator is the proportion who receive beta blockade, patients in the denominator without LV systolic dysfunction are removed, or excluded from the measure calculations. This would be an absolute exclusion.

THREE LEVELS OF TESTING
Just as one needs to check their own work, measures must be tested. I recommend that they be tested at least three times.

• The first is when the idea for the measure set has just been put into a reasonable form. This is “pilot testing” and is very important. It is before the measure is submitted for approval for general use. It is common that the measure set, whether it be about hypertension, eye surgery, or whatever the topic, be tested on a small scale with a designated group experienced in measure testing and see whether it is has validity, whether it is feasible, and whether it can be implemented without undue burden to the provider of care.
• If the measure set is found to be acceptable and is then submitted to the agency that will approve it, either CMS, or NQF, etc., then it is imperative that testing be done again, and data accumulated about the experience when the measure is used more broadly. It is often the case that the shortcomings of the measure become evident only when the general medical community uses the measure. An example was the discovery that if a payer allows no exceptions or exclusions to a measure that the Hemoglobin A1c must be 7% or less, then some patients would be at high risk for hypoglycemia, because their average glucose levels would be lower than the A1c would suggest, as in patients with chronic renal failure.11

Another example would be using a blood pressure goal of under 140 systolic as an accountability measure for all patients, when there are clear medical exceptions of patients in whom such efforts are highly likely to cause severe orthostatic hypotension.
• Finally, the third time one should evaluate the measure is after a year or more has elapsed. The science on which the measure was based may be replaced by newer information, or there may be evidence that the measure did not have any appreciable positive effect on either behavior of providers or improvement of outcomes of importance. Some of us use the term “measure maintenance” for this form of evaluation and testing, and it is necessary to assure the continuing relevance of even the most established measure sets.

Also, among the newer issues one must deal with both at the start of the process and after the measures have been in use, is whether the data is collected and transmitted electronically and what burdens have resulted. It is important that electronic specifications be developed with the measure and, for the most part, most of the societies involved in measure development have outsourced this portion of the development to groups such as the PCPI and the ACC, who have technical expertise in this area. There are complexities that will undermine the efficacy of measures and the ability to implement them broadly, and this work is both laborious and may be expensive.

It is important to always remember that the measure set, when created, has to be tested to make sure that the measure set is collecting the data properly. The gold standard, or reference standard for verification of data elements and procedures, is to compare against a manual review of the paper or electronic record.

There is a special place for composite measures, a measure set that is a combined metric that incorporates multiple individual measures to provide a single score. They may comprise process, structural and intermediate outcomes measures. They could be developed around a clinical disease entity and using only the elements of the measure applicable to the individual patient. An example of such measures would be the percentage of diagnosed patients who received all of the elements of care for which they were eligible. The scoring mechanisms may vary and they are more likely to be unfair when they are scored in an all-or-none fashion, when at least one of the measures may not be appropriate for the patient.
CHALLENGES AND BENEFITS OF MEASUREMENT

Unfortunately, in the 20 years I have been working on performance measure development, there have been many examples of unintended consequences of performance measures, in what I would term a misuse of measures. It is both unfair and counterproductive to penalize physicians because of outcomes that are largely attributable to their patient mix. Also, rewarding physicians primarily on performance measure outcomes may lead to mislocation of services and disruption of organizational behavior. In addition, if an entity insists on complying with measure set performance, the costs may be very high, even excessive.

If the clinician has to spend an inordinate amount of time documenting the measures, it may paradoxically distract them from the clinical process and result in medical errors. Today, increasing numbers of physicians complain of not just the direct, but also the indirect costs of complying with very complex and numerous performance measures and the penalties they face after reporting their results. Their frustration is understandable, for the data that pay-for-performance measurement improves outcomes is just not there. Several studies reported by Campbell in the New England Journal of Medicine in 2007 and 2009, on the outcomes of primary care in the United Kingdom under pay-for-performance, showed that the outcomes were not significantly improved, that perverse incentives took place, and the positive effects were far less than anticipated. While measured outcomes improved initially in a marginal fashion, the quality of care was reduced in several measures not linked to the payment. Continuity of care appeared to worsen as well.12,13

However, there is little question that there is merit to us checking our own work in a formal way, and numerous examples of great improvements made in patient care that were closely linked to major quality improvement efforts. Perhaps the most striking specialty-wide effort was the dramatic change in the safety in the operating rooms from the many improvements made by the American Society of Anesthesiology over the past 25 years, but many other groups, large and small, have done well using principles set forth by Arvedis Donabedian 50 years ago. The most notable successes came when the target for improvement was clinically important, and the other measurements were subordinate to the main goal and were used as quality improvement that helped speed the movement toward the primary goal.

In 2017, physician data measurement will need to begin in order to qualify for MACRA payments effective in 2019. Although the way forward is likely to continue to be a somewhat bumpy one, I still think the best strategy for improving quality of care is to choose a clinically important clinical outcome, develop measurement tools that help achieve that objective without sacrificing other important clinical objectives, and develop and train physicians to lead such an effort. Using the scientific method applied to self-measurement is likely to remain the best and most enduring strategy. Both public reporting and accountability measures will continue to have their advocates and will have their place both now and in the foreseeable future. However, the main engine of positive changes in quality improvement is still likely to be a physician-led, multidisciplinary, multispecialty, robust quality improvement effort using a reasonable and limited number of validated, scientifically based, and clinically tested performance measures that focus on outcomes and safety, yet streamlined to focus on what is most important for high quality patient care. 

Richard Hellman, MD, FACP, FACE, is partner in Hellman & Rosen Endocrine Associates in North Kansas City. He has been the vice chair of the American Medical Association Physician Consortium for Performance Improvement. He gave a presentation on the topic of MACRA and performance measurement to the AMA Advocacy Conference in February 2016. He has achieved recognition by the National Committee for Quality Assurance Diabetes Recognition Program, and has been named a Distinguished Reviewer for the journal Diabetes Care. He is a clinical professor of medicine at the University of Missouri–Kansas City School of Medicine, and a past president of KCMS and the American Association of Clinical Endocrinologists. He can be reached at rhellman@nkccendo.com, or 816-421-3700.

REFERENCES:
“All bleeding stops eventually.”
An axiom in the medical field, this statement rings true most emphatically in the trauma setting. The rapid transition of bleeding in the field to fulminant hemorrhagic shock in the trauma bay is not only devastating for the patient, but a common scenario for the trauma team. As blood loss increases, so does morbidity and mortality. The earliest attempts to control hemorrhage offer the best chances for survival.1

A multidisciplinary approach has evolved over the years to investigate the best modalities for hemostasis in the trauma setting, thereby improving the patient’s survival contingent upon arrival to the appropriate trauma facility.2 Definitive hemorrhage control may ultimately require surgical intervention, a moot point if emergency medical services (EMS) cannot control bleeding and deliver a living patient to the trauma bay. Rapid and effective hemostatic control remains crucial. Knowledge of available tools for hemorrhage control is essential in a time-critical situation.

Mass casualty scenarios have stressed trauma centers. They represent potential devastation that can occur anytime, anywhere. After the country’s deadliest mass shooting in Orlando, Fla., in June, early hemostatic intervention by first responders saved lives. In response to the events of Sandy Hook, Conn., in 2012, where 26 victims—children and adults—were gunned down at an elementary school, the American College of Surgeons released the Hartford Consensus.3 This conference among health care and law enforcement experts created a position statement which emphasized the roles of first responders, including the public, in mass casualty incidents. The consensus statement gave strong emphasis to “early hemorrhage control to improve survival.”

The consensus was updated in 2015, with further recommendations of “bleeding control bags” in public facilities.4 In the event of a mass casualty incident, the presence of hemostatic dressings and tourniquets is crucial to save lives. Available tools for first responders, including concerned citizens, can make a significant and immediate impact on bleeding victims. Global awareness of hemostatic techniques and how to utilize these agents and equipment are strongly encouraged, even mandated, by the Hartford Consensus.

Like all mass casualty incidents, the events in Orlando were unexpected and required a quick response by all available health care personnel. The purpose of this article is to review the variety of hemostatic agents most commonly available for first responders, emergency departments and trauma team personnel, and to improve our own preparedness to deliver optimal patient care in a mass casualty scenario or in a single bleeding individual.

In obtaining hemostasis, there are generally two pathways to be considered: physical and physiologic. Formation of the blood clot, or the physiological response to bleeding, typically begins with vasoconstriction at the bleeding source. Platelet adhesion and soft plug formation ensue, with initiation of the coagulation cascade, and the eventual creation of the fibrin clot.5 Physical hemostasis, while eventually incorporating the body’s physiological response of clot formation, involves direct pressure to compress and stop the bleeding by mechanical force. First-line agents used in the field, such as tourniquets, commonly employ physical hemostasis. Natural induction of the clotting cascade by compression is also utilized by application of topical hemostatic agents, although these agents also impact some component of the physiological process to encourage clot formation. The type and severity of the bleed determines which agent should be used to control hemorrhage.6

PHYSIOLOGICAL AGENTS

Several hemostatic agents have become available recently, having been previously utilized by the military.2,8 In 2006, Pusateri, et al., defined characteristics to consider in evaluating
Modified Rapid Deployment Hemostat (mRDH) is a gauze made of poly-n-acetyl-glucosamine (pGlcNAc) fibers.\textsuperscript{16} Created by Marine Polymer Technologies (Danvers, Mass.), the fibers in mRDH quickly absorb plasma proteins in blood and interact with RBC-receptor specific binders. Secondly, the fibers interact with platelets to initiate clotting and, in particular, (continued on next page)
HEMOSTATIC (continued)

the formation of fibrin. Because of the increased platelet stimulation, increased vasoconstrictive chemokines are released. Studies on mRDH and pGlcNAc date back to the early 2000s, with encouraging results, both for trauma settings and intraoperatively.9,17 At about a thousand dollars per blister pack, mRDH is the most expensive of the agents listed. Due to its cost, mRDH gauze tends to be used in the operating room more frequently than in the field.

QuikClot (Z-Medica, LLC. Wallingford, Conn.) Response Gauze is impregnated with kaolin, which is composed of inert minerals such as silicon, aluminum and magnesium derived from volcanic rock.18 Kaolin absorbs small molecules such as water, increasing the concentration within the blood of clotting factors and platelets. In addition, kaolin also activates Factor XII of the intrinsic clotting cascade pathway, thereby accelerating the clotting cascade process. While the original powder form produced a severely exothermic reaction, resulting in burn injuries, this complication has since been resolved with the introduction of the gauze format.8,10 QuikClot Combat Gauze is vacuum-packaged and Z-folded particularly for use in the military setting, and is the only product endorsed by the Committee on Tactical Combat Casualty Care (CoTCCC) as a hemostatic topical agent to be used by medical personnel in the combat arena.19,20 The cost of the combat gauze roll is $43. The QuikClot Trauma Pad was created for surgeon use in the operating room.

Beeken Biomedical’s (Stoughton, MA) line of NuStat products are made of Hemafiber Technology, a composition created by the company.21 Hemafiber is an interwoven matrix of cellulose and silica-based fibers. The former absorbs fluid and binds to red blood cells, resulting in a higher concentration of clotting factors. The silica component increases platelet activation and platelet recruitment at the injury site, thereby increasing plug formation. NuStat Tactical Gauze was created specifically for the trauma setting and is composed of Hemafiber, with instructions to apply pressure during packing if necessary. Hills, et al., studied 15 swine, comparing NuStat to Combat Gauze, showed comparable efficacy. NuStat has become increasingly used in trauma in the last two years.22 One NuStat Tactical Gauze is approximately $27.

For historical interest, TraumaCure’s (Bethesda, Md.) WoundStat was a powder composed of smectite, a nonmetallic clay in granule form that becomes a paste after absorbing water.2 This agent had been tested, with other agents, by the U.S. Army’s Institute of Surgical Research (USAISR).15 While WoundStat was found to be as effective as Combat Gauze and chitosan agents, it was found to cause injury to blood vessels. There was a risk of dissemination, causing thrombosis throughout the body. In 2008, a statement was released by the U.S. Army regarding cessation of its use. FDA approval was revoked in 2009. Its use is no longer recommended.23

Guidelines from the Committee on Tactical Combat Casualty Care (TCCC) recommended Combat Gauze

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<table>
<thead>
<tr>
<th>Hemostatic Agent</th>
<th>Brand</th>
<th>Active Ingredient</th>
<th>Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>ChitoGauze PRO</td>
<td>Tricol (formerly HemCon)</td>
<td>Chitosan</td>
<td>4 in. x 4 in. x 4 yd. $192.20 for five (~$38.44)</td>
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<td></td>
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<tr>
<td></td>
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</tr>
<tr>
<td>Celox EMS Gauze</td>
<td>Celox</td>
<td>Chitosan granules</td>
<td>4 in. x 4 in. $15.60 for two (~$7.80)</td>
</tr>
<tr>
<td>CeloxA syringe</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>mRDH</td>
<td>Marine Polymer</td>
<td>pGlcNAc fibers</td>
<td>4 in. x 4 in. blister pack $3120 for three (~$1040)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>QuikClot</td>
<td>Z Medica</td>
<td>Kaolin</td>
<td>4 in. x 4 in. $269 for ten (~$26.90)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>NuStat Tactical</td>
<td>Beeken</td>
<td>Hemafiber (cellulose/silica)</td>
<td>4 in. x 4 in. $269 for ten (~$26.90)</td>
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<td></td>
</tr>
<tr>
<td>xStat xGauze</td>
<td>Revmedx</td>
<td>expanding sponge</td>
<td>One syringe: $425</td>
</tr>
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<td></td>
<td></td>
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<td></td>
</tr>
</tbody>
</table>

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Table 2. List of Hemostatic Dressings

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Image 1. XStat Syringe
as the first choice for military use on the battlefield. Studies of its effectiveness have been matched by other agents during animal test trials. Recent research by the USAISR has endorsed the use of chitosan products, such as ChitoGauze, as a secondary line agent. The CoTCCC’s Tactical Combat Casualty Care (TCCC) updated its 2015 guidelines to include this recommendation.24

Unique among hemostatic agents is xStat by Revmedx (Wilsonville, Ore.), a syringe-type device that fills wound cavities with small sponges (Image 1).25 These sponges quickly expand upon contact with blood, creating a tamponade effect within a bleeding cavity. The company advertises the product as “filling” the cavity within 20 seconds. Each expanding sponge is lined with an X-ray detectable marker for ease of removal, as the sponges are non-absorbable. Bleeding control can be obtained for up to four hours, and is ideal for non-compressible life-threatening bleeding at “junctional” wounds, such as the groin, where tourniquets are not as easily deployed. One syringe of xStat is approximately $425. Unfortunately, xStat is contraindicated for most large surface area wounds of the chest and abdomen. This product is one of the newer agents, having been created for the military setting in 2014. It was approved by the FDA within the last year for civilian trauma use.26 A dressing lined with the rapidly expanding sponge, xGauze, is also available from the same company, priced at about $50 per gauze roll (Table 2).25

**TOURNIQUETS**

Bleeding control using topical agents, alone or with direct pressure, would be ideal. Life-threatening hemorrhage is not so easily controlled. Tourniquets have been used for centuries. Applying a sufficient compression force proximal to the bleeding will occlude and stop bleeding. A tourniquet can be any device that can execute this. Easy access to commercially made tourniquets by first responders and other health care personnel has become the standard of care. The use of makeshift tourniquets should be avoided except in extreme scenarios.27 There are various types of tourniquets that have become commercially available.5 All tourniquets have the same goal: direct cessation of hemorrhage by applying force (compression) to the bleeding vessel.

Tourniquets are not without consequences. Surrounding structures, such as nerves and muscles, can be damaged by tourniquet compression. Permanent nerve injury or muscle damage may be seen following only two hours of tourniquet application. Tourniquets often require compression of an artery supplying an entire extremity. This causes distal ischemia, with lactic acidosis on release of the compression. Permanent muscle damage can occur within six hours of tourniquet application. Prolonged tourniquet use can result in limb loss requiring an amputation, if the wounding mechanism has not already done so.27,28 After using any sort of tourniquet, the time should be recorded on a piece of tape, placed next to the tourniquet.

Despite possible complications, tourniquets save lives when used correctly. They are essential to treat life-threatening extremity hemorrhage. In 2014, a review by the American College of Surgeons Committee on Trauma strongly recommended the use of tourniquets in the prehospital setting.7 The CoTCCC 2015 guidelines encouraged the use of limb tourniquets for hemostatic control in severe bleeding.24 In particular, the guidelines mention placement over clothing, and as proximal as possible, when the provider is unable to definitively delineate the source of bleeding. If the source is identified, however, the tourniquet should be placed a few inches proximal to the wound. Should hemostasis be unsuccessful, an additional tourniquet may be placed more proximally. Maximal tourniquet time should be two hours. But if it has been placed for more than six hours, the tourniquet (continued on next page)

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**Table 2. List of Hemostatic Dressings**

<table>
<thead>
<tr>
<th>Product</th>
<th>Brand</th>
<th>Indications/Location</th>
<th>Cost</th>
</tr>
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<tbody>
<tr>
<td>xGauze</td>
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<tr>
<td>xStat</td>
<td></td>
<td></td>
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<tr>
<td>NuStat Tactical Beeken Hemafiber</td>
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<td></td>
<td></td>
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<tr>
<td>QuikClot Z Medica Kaolin 4 in. x 4 in.</td>
<td></td>
<td></td>
<td>$22</td>
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<tr>
<td>mRDH Marine Polymer pGIcNAc fibers 4 in. x 4</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>in. blister pack</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Celox-A syringe</td>
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<td></td>
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<tr>
<td>Celox EMS Gauze</td>
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<td></td>
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<tr>
<td>ChitoFlex</td>
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<td>ChitoGauze PRO</td>
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<td>Hemostatic Agent Brand</td>
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<tr>
<td>Cost</td>
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<tr>
<td>Celox Chitosan granules 4 in. x 4 in.</td>
<td>formerly</td>
<td>(formerly HemCon)</td>
<td>$49.99</td>
</tr>
<tr>
<td>Tricol (cellulose/silica)</td>
<td></td>
<td>Chitosan 4 in. x 4 in. x 4 yd.</td>
<td>$26.95</td>
</tr>
<tr>
<td></td>
<td></td>
<td>4 in. x 35 in. rolled gauze</td>
<td>$269 for ten (~$26.90)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>4 in. x 4 in.</td>
<td>$3120 for three (~$1040)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1 in. x 3 in. x 28 in.</td>
<td>$192.20 for five (~$38.44)</td>
</tr>
<tr>
<td></td>
<td></td>
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</tr>
<tr>
<td><strong>Table 3. List of Junctional Tourniquets</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Product</td>
<td>Brand</td>
<td>Indications/Location</td>
<td>Cost</td>
</tr>
<tr>
<td>Sam Junctional Tourniquet (SJT)</td>
<td>SAM Medical</td>
<td>Axillas, Groins, Pelvic fractures</td>
<td>$350</td>
</tr>
<tr>
<td>Combat Ready Clamp (CRoC)</td>
<td>Combat Medical</td>
<td>Carotids, Axilloe, Iliaos, Umbilicus</td>
<td>$760</td>
</tr>
<tr>
<td>Junctional Emergency Treatment Tool (JETT)</td>
<td>North American Rescue</td>
<td>Groin (high thigh/grain wounds)</td>
<td>$360</td>
</tr>
</tbody>
</table>
HEMOSTATIC (continued) should not be removed until the patient has been transferred to a surgical facility. Although CoTCCC guidelines were not specifically created for the civilian trauma setting, the recommendations are still applicable. Especially in the urban setting, EMS transport and field tourniquet times can be minutes or hours.

One of the most common tourniquets utilized by both military and civilian providers is the Combat Application Tourniquet (C-A-T). This tourniquet is available to all first responders, including police and firefighters. It is one of the most commonly used tourniquets by the military, having been studied and compared to other tourniquets by the USAISR over a decade ago. The C-A-T has four parts: the band, a friction buckle, a rod and a strap. Once the tourniquet is placed proximal to the bleeding site, the band is pulled tightly and is adherent to itself, allowing the person to lock the rod into the strap. The band tail is then passed into its friction buckle, enabling a one-way tightening system. The tourniquet pressure—and mechanism for bleeding control—is then achieved with twisting of the rod, tightening the band until hemorrhage control is achieved. The rod is then secured in the strap (Image 2).

Newer types of tourniquets have been released over the last few years, aiming at more specific locations for hemorrhage control while minimizing the potential consequences of a circumferential tourniquet application. Difficult areas to access and control, such as the axilla and inguinal regions, have given rise to the development of junctional tourniquets. Of those available, there are three recommended tourniquets utilized by the military according to the CoTCCC that have also been FDA approved for civilian scenarios: Combat Ready Clamp (C RoC), Junctional Emergency Treatment Tool (JETT) and the SAM Junctional Tourniquet (SJT) (Table 3).

The only tourniquet also approved by the FDA for pelvic fracture stabilization, the SAM Junctional Tourniquet (SJT) by SAM Medical (Wilsonville, Ore.) is a belt with compression devices attached, called Target Compression Device (TCD) (Image 3). The only tourniquet also approved by the FDA for pelvic fracture stabilization, the SAM Junctional Tourniquet (SJT) by SAM Medical (Wilsonville, Ore.) is a belt with compression devices attached, called Target Compression Device (TCD) (Image 3). The TCD is placed proximal to the bleeding site, the band is pulled tightly and is adherent to itself, allowing the person to lock the rod into the strap. The band tail is then passed into its friction buckle, enabling a one-way tightening system. The tourniquet pressure—and mechanism for bleeding control—is then achieved with twisting of the rod, tightening the band until hemorrhage control is achieved. The rod is then secured in the strap (Image 2).

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as a last resort, at the umbilicus or the aortic bifurcation. Easy to assemble, the pressure disk must be placed at precise locations to be effective in occluding major vessels. Additional education is required to review anatomic landmarks and to assure proper and safe placement. One tourniquet costs about $760.

North American Rescue's (Greer, S.C.) Junctional Emergency Treatment Tool (JETT) is specifically designated for lower extremity wounds, particularly in the thigh or groin. Like newer tourniquets, the JETT does not apply occlusive pressure circumferentially. The belt has two devices attached to compression pads overlying the groin. These compression pads are attached to a pedal-shaped wedge, which is prepositioned prior to rotation of the wedge to angle along the inguinal area. Once the belt has been tightened down, the handle over the compression pads is rotated until effective compression is obtained. Crucial to its success is the appropriate alignment of the wedges, or footprints, along the groin. Unlike other devices, with its bilateral groin compression pads, the JETT can be used unilaterally or on both lower extremities simultaneously. Pricing for a JETT is around $360.

A unique tool emerging for hemorrhage control in the prehospital setting is the iTClamp by iTraumaCare (San Antonio, Tex.) (Image 5). Marketed for use on an extremity, in the axilla, at inguinal regions or scalp and neck, the FDA-approved iTClamp looks like a clip, applied at the wound site edges. Hemostasis is obtained by physical clamping at the wound edges, thereby sealing the wound and creating a contained hematoma that tamponades the bleeding source. The iTClamp costs approximately $100. One report regarding use of this device demonstrated successful hemostasis in nine of ten patients, with an average time of ten seconds for application.

CONCLUSION
Life-threatening hemorrhage, unlike the interventions to control it, is an unchanging phenomenon. Damage control techniques and cessation of hemorrhage are time-sensitive. The magnitude of the new hemostatic agents being developed out of our military conflicts is impressive, and can correlate with daily civilian applications. Tourniquets have been shown to be effective, should be used early in specific cases, and applied appropriately. The usage of junctional tourniquets may also become more commonplace in the civilian trauma setting. Knowledge of all these tools is important for any health care provider providing care to an injured patient, so that not only is the bleeding stopped, but a life is saved.

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REFERENCES

(continued on page 27)
In the recent conflicts in Iraq and Afghanistan, thoracic trauma has been responsible for one quarter of battle-field deaths and up to 20% of all war injuries. On the other hand, isolated injury to the esophagus is rare. Management of these injuries has changed in recent years. The esophagus is subject to distinct categories of injuries: 1) caustic or chemical injury, 2) operative and spontaneous, 3) blunt, and 4) penetrating. Management of each of these categories is determined by the etiology.

**CAUSTIC INJURY**

Corrosive chemical injuries of the esophagus are the result of ingestion of either strong acids or strong bases. Acid injury is associated with coagulation necrosis and base injury with liquefaction necrosis. Strong acids include hydrochloric and sulfuric acids, and common strong base ingestions include sodium and potassium hydroxide, common drain and oven cleaners, concentrated dishwasher and laundry detergent “pods,” as well as small batteries. The majority of toxic ingestions occur in children but are also seen in adults. In the early evaluation of these patients, it is essential to determine the material that has been ingested. Mouth burns may or may not be present, however esophageal perforation and stomach necrosis can occur. Stomach and duodenal perforation are most likely in adults, and all should be screened with CT of the abdomen to exclude perforation.

All patients should be admitted to the hospital and receive intravenous fluid resuscitation and broad spectrum antibiotics. Parenteral corticosteroids are probably not helpful. Early endoscopy with the smallest endoscope available and with minimal insufflation, just to the most proximal level of injury, is recommended. The scope should be advanced no further because of risk of perforation.

If the injury is severe an open or laparoscopic gastrostomy is recommended, with retrograde passage of a string to guide future retrograde dilatation. The esophagus is generally allowed to heal three-plus weeks before dilatation is undertaken.

Management of the patient is determined by the depth of injury. Grade one lesions can generally be managed by a period of NPO with IV fluids until the patient is able to swallow their saliva. Patients with grade two lesions are kept NPO and supported with IVFs until they can swallow their saliva without pain. Parenteral nutrition is usually required. Non-acidic clear liquids are then begun and diet advanced to a soft mechanical diet for two to three weeks. Endoscopy is repeated after three weeks. Third-degree injuries are managed in a similar fashion. Patients are kept NPO and supported until they can swallow their saliva and gastrointestinal function returns. The patient may be discharged home when they are able to take solid food.

Strictures may develop after any esophageal injury, but are more common with grade two or three injuries. They generally take more than three weeks to develop, so contrast studies and repeat endoscopy are performed after three weeks. Mild strictures have minimal reduction of the esophageal lumen. Moderate strictures have up to 50% reduction. Severe strictures have more than 50% reduction and are associated with dysphagia and odynophagia. Antegrade dilatation with Maloney dilators or balloon dilatation can be used to treat mild or moderate strictures. But severe strictures should be dilated in a retrograde fashion. Stents may be used. Surgical intervention may be required to handle longstanding strictures that fail to respond to repeated dilatation and/or stenting. A transhiatal approach is preferred.
OPERATIVE AND SPONTANEOUS INJURIES

Operative injuries to the esophagus occur at two levels where the esophagus is the narrowest: the junction of the inferior constrictor and the cricopharyngeus muscle in the cervical esophagus, and secondly the gastro-esophageal junction. Injuries may be internal or external. There are three general categories of these injuries: instrumental, non-instrumental and foreign bodies. In children, foreign bodies may lodge a third level of narrowing at the level of the aortic arch. Fortunately, these injuries are managed in similar fashion regardless of the etiology.

Endoscopic removal is the treatment of choice for foreign bodies. Surgical intervention may be required if the foreign body cannot be removed endoscopically, or if there is evidence of esophageal perforation. If there is associated hematemesis, surgical intervention should be carried out emergently.

Cervical perforation of the esophagus is associated with pain, stiffness of the neck, dysphagia, dysphonia and occasionally respiratory distress. On examination, cervical crepitus is commonly present. Radiographic evaluation shows mediastinal and subcutaneous air in the fascial planes and widening of the retrovisceral space. The neck is tender to palpation, and the pain is worsened with movement of the thyroid cartilage by the examiner. Fever and leukocytosis develop quickly.

Esophagram with water-soluble contrast should be done to establish the site and extent of the perforation. But this study is unable to detect 50% of cervical perforations and 15% to 25% of thoracic perforations. So, if clinical suspicion is high but no esophageal leakage is shown, the esophagram should be repeated with dilute barium. Alternately a CT scan of the neck and chest with oral contrast is a more sensitive study. Esophagoscopy may be especially helpful in establishing a diagnosis in cases of foreign-body perforation or penetrating trauma. With clinical and radiographic findings as previously described, a negative esophageal contrast study should not preclude surgical exploration. In cases of instrumental perforation, neither contrast esophagram nor repeat endoscopy is indicated. Cervical exploration, two-layer closure of the perforation, and adequate drainage of the visceral compartment are the goals of therapy. But this must be done early. If the injury is recognized more than 12 hours following perforation, intervention should be limited to exploration and drainage with no effort to close the perforation.

Perforation of the thoracic esophagus is more problematic, and recommendations for management have recently changed. If perforations are minimal and contained, expectant management with antibiotics, IV fluids and abstinence from oral intake may be all that is required. Most often however, the perforation is full thickness and involves the mediastinal pleura, which can lead to contamination of one or both pleural spaces. Clinical symptoms include pain, radiating to the back, epigastrum or precordium and even pleuritic chest pain if the pleural space is involved. Fever, tachycardia, dysphagia and reperatory distress are common. On examination, the patient is frequently in extremis, with guarded respirations and hypotension. Use of either fluoroscopy or CT scan with water-soluble oral contrast is diagnostic. Hydropneumothorax and a widened mediastinum with mediastinal emphysema are usually present.

It is of utmost importance that the perforation is recognized promptly and treatment initiated. The goals of therapy are 1) elimination of the source of mediastinal and pleural contamination, 2) adequate drainage of the pleural space and mediastinum, 3) support with broad-spectrum antibiotics, and 4) maintenance of adequate nutrition. Traditionally, the esophagus is exposed through a left thoracotomy, the perforation debrided to healthy tissue, and an interrupted two-layer closure of the mucosa and muscularis is performed. The closure is then buttressed with an intercostal muscle flap, omentum, parietal pleura, pericardial fat pad or a portion of the diaphragm. Drainage of the mediastinum and pleura are essential. The addition of both a gastrostomy and feeding jejunostomy are

When recognized promptly, both operative and spontaneous perforations can be managed with pleural and mediastinal drainage and placement of a covered stent in the esophagus.
ESOPHAGEAL TRAUMA (continued) recommended.

This is still the recommended approach for perforations that are recognized more than 24 hours after they have occurred. When recognized promptly, both operative and spontaneous perforations can be managed with pleural and mediastinal drainage and placement of a covered stent in the esophagus. Endoscopic suturing of the perforated esophagus, with the addition of a covered stent, has been recommended recently. If a leak persists 24-48 hours after open repair and drainage, when a contrast study is performed, a covered stent is placed. If esophageal injury and perforation occur at the time of a paraesophageal hernia repair or antireflux procedure, direct repair of the injury is the preferred approach.

If perforation occurs in the setting of a carcinoma or other serious esophageal disease, surgical resection may be the best option for management. Most experts agree that pleural drainage and an expectant approach to esophageal perforations is suboptimal and followed by frequent failure and death of the patient.

BLUNT TRAUMA

Because of the relatively protected position of the esophagus, blunt trauma to the esophagus is infrequent, but may occur with deceleration injuries to the chest, CPR, the Heimlich maneuver and blast injuries. The esophagus and adjacent membranous trachea may both be involved. Approximately one third of acquired tracheoesophageal fistulas are created in this fashion. These injuries are most often associated with multiple-system trauma, which may delay the diagnosis. Once the injury has been identified and the patient has been stabilized, direct repair is undertaken by right thoracotomy. The repair is reinforced with either interposition of intercostal muscle or pleura. A tracheostomy is generally placed to protect the tracheal suture line.

PENETRATING TRAUMA

Management of non-instrumental penetrating injuries to the esophagus is again determined by the location of the injury. The chest wall, great vessels, trachea and major bronchi, pulmonary vessels, heart and diaphragm may all be involved. Rapid evaluation is paramount, as the patient can rapidly deteriorate because of cardiac tamponade, tension pneumothorax or massive intrathoracic hemorrhage. Initial survey is very important: upper and lower thoracic wounds may also involve neck and abdominal structures, respectively. Stab wounds and gunshot wounds differ in the degree of penetration and damage to surrounding tissues. High-velocity injuries with rifle ammunition will obviously cause more adjacent injury than low-velocity rounds from handguns.

Fortunately, penetrating injuries to the thoracic esophagus are rare. The cervical esophagus is injured more frequently. But when they occur, injuries to the thoracic esophagus are associated with other major organ injuries in up to 98% of cases. A multicenter study of penetrating esophageal injuries showed that a prolonged preoperative workup resulted in delay in diagnosis and poor outcomes. Rapid evaluation should be performed, and if delay is anticipated, surgical exploration undertaken in the operating room.

Evaluation of these patients includes emergent CT angiogram and water-soluble contrast via the nasogastric tube, to quickly define or exclude...
the nature of the injuries. If the patient is unstable and unable to have a contrast study, the patient is transferred to the operating room. They should be evaluated by flexible bronchoscopy and esophagoscopy. Flexible endoscopy has been demonstrated to be an excellent diagnostic tool to evaluate for esophageal traumatic injuries. The site of injury determines the route of surgical exploration. A left thoracotomy is performed if the site of injury is uncertain, so the descending thoracic aorta may be clamped if necessary. Direct two-layer repair of the esophageal injury with wide drainage is the treatment of choice, and identification of the esophageal injury at the time of exploration is critical. A contrast esophagram on postoperative day seven is recommended unless there is evidence of a postoperative leak, with purulent chest tube drainage. A covered esophageal stent is useful in the case of a persistent leak.

CONCLUSION

The management of esophageal injuries has evolved in recent years to include more common use of covered esophageal stents for instrumental and spontaneous esophageal perforations. Isolated esophageal injuries are infrequent. However, we have presented a rational treatment plan for patients suffering these injuries.

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HEMOSTATIC (continued from page 23)

The management and resuscitation of bleeding and coagulopathic trauma patients has been a renewed area of research, especially during the wars of the last 25 years. Trauma surgeons have been working towards perfecting treatment algorithms that not only improve survival, but also decrease the patient’s morbidity. But what laboratory studies should be used as a guide for blood product resuscitation? Thromboelastography (TEG) was developed in 1948. It has only recently been gaining worldwide attention for resuscitation of the injured patient. TEG has the potential to radically change the protocols of blood component resuscitation, while improving patient outcomes and reducing blood product waste. The purpose of this article is to introduce the reader to TEG, and to discuss the benefits of this technology to guide the administration of blood products to the critically ill and injured patient.

BACKGROUND

A review of the clotting process is necessary to understand TEG. In the uninjured patient setting, the coagulation process is mediated by anti-thrombogenic factors such as protein C and S, tissue factor plasminogen inhibitor and anti-thrombin, in order to maintain homeostasis and prevent unnecessary thrombogenesis. When this delicate equilibrium is altered, a hypocoagulable or hypercoagulable state develops. Worse, the injured patient may have hemorrhage and thrombogenesis occurring simultaneously, complicating resuscitation and injury care. Damage to a blood vessel results in vasoconstriction and release of proinflammatory and prothrombotic mediators. Platelet aggregation propagates to the development of a soft plug. The clotting cascade is activated.

The clotting cascade is most commonly divided into the intrinsic and extrinsic pathways. Damage to the vessel that results in exposure of collagen within the extracellular matrix of the vessel initiates the intrinsic pathway. Collagen exposure results in activation of factor XII, which then serially activates factors IX and X. The extrinsic pathway is instigated by release of tissue factor from damaged endothelial cells. Tissue factor activates factor VII which then activates factor X. Once factor X is activated, the rest of the clotting cascade is known as the common pathway. This ends with conversion of prothrombin to thrombin, which cleaves fibrinogen to fibrin to form the clot. Fibrin then activates factor XIII, which allows fibrin polymers to crosslink platelets together to cause clot stabilization.

Image 1. Coagulation Cascade. Source: American Family Physician
very important step in this intricate cascade is fibrinolysis. Fibrinolysis is activated upon initiation of the clotting cascade and acts as a negative feedback mechanism for thrombogenesis. Tissue plasminogen activator, plasmin and alpha-2 anti-plasmin are key ingredients in limiting clot propagation (Image 1).2

Conventional coagulation tests such as prothrombin time (PT), activated partial thromboplastin time (aPTT) and international normalized ratio (INR), can provide insight into the cascade. The intrinsic pathway can be monitored with aPTT. Heparin activates antithrombin III, which binds and inhibits multiple factors including factors IX, X and XI. Heparin alters aPTT values.4 The extrinsic pathway can be correlated with PT and INR. Warfarin is a common anticoagulant that works by decreasing the vitamin K dependent factors, which include II, VII, IX and X, whose effect will be shown by PT and INR abnormalities.4

But monitoring the coagulation cascade has largely focused on monitoring the effects of heparin and warfarin, and something more is needed in care of the injured patient.

Thromboelastography is a visco-elastic point of care test that can assess whole blood coagulation in real time.5 TEG works by taking a small sample of whole blood and placing it in a small cylindrical cup. A pin on a stationary torsion wire is then suspended in the blood specimen. As the cup continuously oscillates, the viscoelastic changes are transduced via the torsion wire and traced as a real-time graphic representation (Image 2).5 There is an additional system, rotational thromboelastography (ROTEM), in which the pin rotates in the blood specimen while the cylindrical cup remains stationary. Although the tests report similar results, they are not interchangeable and different nomenclature is used.6

TEG is the more established test, and is the focus of this article. Once the test begins, the pin and wire begin to detect the viscoelastic changes which appear as a graphic depiction of real-time coagulation and fibrinolysis. The reaction time (R-time) depicts enzymatic clot formation (Image 3). The next portion of the graph is the K time, which is defined as the time required for clot amplitude to reach 20mm.5 The α-angle is the slope of the angle from clot initiation (R-time) to the developing curve, or in other words, the speed of clot formation.7 Maximum amplitude (MA) represents clot strength. Clot lysis (CL) represents fibrinolysis, or clot breakdown, which is typically measured at 30 and 60 minutes.7

Currently, prothrombin time (PT), activated partial thromboplastin time (aPTT), international normalized ratio (INR), platelet count and fibrinogen are some of the most commonly used laboratory tests to assess for coagulopathy in trauma patients. These tests are commonly referred to as conventional coagulation testing (CCT).8 Each value is an individual snapshot of only a few of the multiple components integral to the clotting cascade. Current laboratory tests provide the physician with a snapshot of the initial intrinsic (aPTT) and extrinsic (PT, INR) pathways, with platelet and fibrinogen levels, but no single test looks at the common pathway, or fibrinolysis, or the clotting (continued on next page)
that there were strong correlations between PT, aPTT, INR to K time and R time and a moderate correlation between α-angle and MA to platelet count, PT and a PTT. That being said, Cotton’s study showed that r-TEG values were able to predict requirement of early blood component transfusions within minutes of test initiation. CCT’s provide only a narrow view of the intrinsic, extrinsic pathways, and the platelet count, in contrast to the comprehensive view provided by TEG. Given the complex coagulopathies seen in trauma patients, such qualitative information is essential. An added feature of TEG, in comparison to CCTs, is the ability to detect not only hypercoagulable, but also hyperfibrinolytic trauma patients.

TEG NORMAL/ABNORMAL BLOOD PRODUCTS NEEDED

A basic understanding of how TEG works and what each value correlates with in the clotting cascade, will direct the health care provider towards the specific factors that need to be replaced (Image 4). When evaluating a TEG tracing, each portion of the graph relates to specific factors in the clotting cascade. Please relate each example below with its corresponding TEG tracing.

- **Prolonged R time**: Delayed initiation of clot formation, usually due to a low level of clotting factors. Appropriate intervention: fresh frozen plasma (FFP).
- **Decreased α-angle**: A slow rate of ongoing clot formation. Appropriate intervention: cryoprecipitate. Cryoprecipitate is high in factor VIII, von Willebrand factor, fibrinogen, ADAMTS12, fibrinonectin and factor XIII.
- **Decreased MA**: Weak clot strength. Appropriate intervention: platelets, consider DDAVP. Regardless of whether the quantitative platelet count is low, or the functional status of the platelets is poor (uremic patient, antiplatelet medications), the MA will be decreased.
- **Percentage decrease in the amplitude at 30 minutes**: A state of hyperfibrinolysis. Appropriate intervention: tranexamic acid, aprotinin, aminocaproic acid (all interfere with plasminogen activation or the plasmin molecule inhibiting fibrinolysis).
- **Shortened R time, increased MA**: A hypercoagulable state. Appropriate intervention: no products, consider pRBC. Carefully consider anticoagulation if there is no evidence of continued bleeding.

Of note, the patient can have any combination of abnormalities at one time. Most trauma patients have multiple deficiencies that require multiple blood products. A repeat TEG after appropriate blood product intervention should graphically show the TEG tracing normalize.

**BENEFITS OF TEG**

In a prospective study by Cotton, et al., rapid TEG (r-TEG) and CCTs were compared for timeliness of results. The r-TEG differs from TEG in that tissue factor (in addition to standard kaolin) is used to accelerate activation of the clotting cascade (8). In this study, monitors were placed in the trauma bay, which allowed the TEG tracing to be viewed as it was developing in real time. They found that early r-TEG results (R time and K time) were available as early as 5.1 minutes. Late r-TEG values (α-angle and MA) were
available within 14.9 minutes. Final r-TEG values (CL30) were available within 27 minutes. The time to final r-TEG results, 27 minutes, was comparable to PT, aPTT and INR results (27 minutes) and platelet count (23 minutes). Early and late TEG results provide valuable information that allows the health care provider to quickly tailor the blood product resuscitation to the unique needs of the coagulopathic patient.

Holcomb, et al., conducted a retrospective study that looked at cost efficiency of r-TEG with the most commonly used CCTs (INR, PT, aPTT, platelet count and fibrinogen). They found that TEG had similar cost, but faster results that more accurately predicted the need for early and massive transfusion. The Surgical Critical Care guidelines for TEG beautifully summarize Holcomb and colleagues’ results, “The authors found that R time predicted RBC transfusion and α-angle predicted massive transfusion better than PT or PTT. The α-angle was superior to fibrinogen in predicting plasma transfusion, and the MA was superior to platelet count in predicting [the need for] platelet transfusion.” Interestingly, both of the institutions involved in the Cotton and Holcomb studies, have ceased ordering CCTs and rely solely on r-TEG results to guide their treatment of severely injured patients.

Current guidelines for the initiation of the massive transfusion protocol (MTP) have been provided by the PROPPR Randomized Clinical Trial which recommended early administration of FFP, platelets and red blood cells in a 1:1:1 ratio. Although no mortality difference was found when comparing 1:1:1 ratio with 1:1:2 ratio, there were more patients in the 1:1:1 group who achieved hemostasis, and there were fewer deaths secondary to exsanguination. A study by Tapia, et al., challenged the current 1:1:1 regimen. The center had routinely been using TEG to guide trauma blood product resuscitation for years prior to the 1:1:1 guideline publication. Their center updated their MTP to follow the 1:1:1 ratio and started a retrospective review to compare their TEG directed results versus the predetermined 1:1:1 strategy. In this review, there was no difference in mortality for blunt trauma victims requiring 6 units or more red blood cells. Of note, using the 1:1:1 rule was associated with a significant increase in mortality among penetrating trauma victims requiring 10 units or more RBC. Tapia, et al., proposed that in the 1:1:1 arm, FFP may have been less aggressively utilized as a predetermined amount of FFP was given rather than guided by real time data provided by the TEG.

THEORETICAL BENEFITS AND FUTURE GOALS OF TEG

Thromboelastography seems to be a diamond in the rough for trauma resuscitations. Why is this test not utilized more consistently across trauma centers? There is a constellation of reasons: cost, lack of health care provider education, lack of comfort with the technology, lack of accessibility to equipment and lack of randomized controlled trials. In a day and age where improved outcomes are demanded, in conjunction with improved cost efficiency, TEG may become an everyday term in trauma community. Goal-directed blood product administration would allow physicians to create patient-specific resuscitation ratios that would conserve blood, while also decreasing the morbidity and mortality associated with blood transfusions, possibly including ARDS and multiple organ failure. Randomized controlled trials are required to truly determine the role of TEG in trauma. TEG has been thoroughly studied in regards to cardiac and liver transplantation and is central to guiding blood product administration in these clinical settings. Tapia, et al., suggest that TEG used in conjunction with massive transfusion protocols may be the optimal approach.

Thromboelastography, a real-time view into the clotting cascade, is an exciting test that has the conceivable ability to allow goal-directed blood product resuscitation and blood conservation while also improving patient outcomes.

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**Shifts in the Microbiome Impact Tissue Repair and Regeneration**

Researchers at the Stowers Institute for Medical Research have established a definitive link between the makeup of the microbiome, the host immune response, and an organism’s ability to heal itself.

They showed that a dramatic shift in the microbial community of planaria robs the freshwater flatworm of its superior regenerative abilities. This same shift has been observed in human inflammatory disorders, though previous attempts to mimic it in lower organisms like fruit flies or zebrafish have proved unsuccessful.

The study, published in the journal *eLife*, provides a valuable model for uncovering the basic molecular mechanisms governing the interplay of immunity and regeneration, and could point the way toward new therapies to combat serious human ailments like chronic non-healing wounds.

“This is the first animal model to link pathological shifts in endogenous bacteria with the inhibition of regeneration,” says Alejandro Sánchez Alvarado, PhD, an investigator at the Stowers Institute and the Howard Hughes Medical Institute, and senior author of the study. “We know that some kinds of bacteria are critical to our health, and that other kinds of bacteria can make it very difficult for us to recover from illness. Now we can study how the changing nature of the microbiome—and the way the immune system responds to those changes—impacts the natural execution of regenerative processes.”

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**TEG (continued)**


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**PERFORMANCE MEASURES (continued from page 17)**


War and Trauma: A History of Military Medicine

SYSTEM EVOLVES TO TODAY’S HIGH STANDARD OF PUBLIC HEALTH AND CASUALTY CARE

By Charles W. Van Way, III, MD, Col., USAR-MD, Retired

While military medicine by the beginning of the 19th century looked much better than at any time in the previous millennia and a half, both trauma care and military public health were primitive by today’s standards. The development of what we now know as modern military medicine occurred over the course of the late 19th century and into the 20th. While this evolution took place across Europe as well as in North America, we will concentrate upon the American experience. The European experience was essentially similar. Medical and trauma care made slow progress during the limited wars of the 19th century, but was greatly challenged by smaller wars in adverse environments. In the case of Europe, those would be the Crimean War and then the Boer War in South Africa. In our experience, this would be in the Caribbean and the Far East.

After the Napoleonic wars, which included our War of 1812, the United States had few major conflicts for 50 years. But that period of calm was followed by the bloodiest conflict in our history. The American Civil War was fought with mass armies, modern industrial technology, railroad transportation and telegraphic communications. Unfortunately, its health care was barely up to the 18th century. Both armies had physicians, but there was only a rudimentary hospital and evacuation system. Both armies depended heavily upon civilian physicians and makeshift facilities to care for their injured soldiers. Even “army doctors” were contracted civilians. Public health was terrible. Many soldiers died of disease, often even before reaching the battlefield. Sanitation was abysmal. Epidemics of dysentery, pneumonia (“camp lung”) and typhus swept the camps. And yet, nothing was done during or after the war to change things.

PUBLIC OUTCRY AGAINST DISEASE LEADS TO IMPROVEMENTS

The next war, the brief Spanish-American War (1898), was fought in the tropics, notably Cuba and the Philippines. Typhoid, yellow fever and malaria were new to American troops, and killed far more than enemy action. There was little organization, few supplies and poor use of resources. But the war was highly publicized in the newspapers of the day. After the war, there was a great public outcry about disease. The so-called “typhoid board,” often called the Reed Commission, was set up during the war, and made a number of recommendations about sanitation, malaria control and mosquito control. The Reed Commission paved the way for the construction of the Panama Canal, overcoming the high rate of yellow fever among the workers in previous attempts to dig an Atlantic to Pacific canal. Walter Reed was an outstanding Army physician, one of the true heroes of the Army Medical Corps (Fig. 1). He had immense influence during and after the war. He died in 1902 of appendicitis, but his work was carried on. The subsequent Dodge Commission conducted a much more comprehensive review of the shortcomings of the Army medical services. These included poor preparation, poor sanitation in the camps, and failure to organize nursing (continued on next page)
services. As a result, there was a major re-organization of the Army's medical support. So finally, during the first decade of the 20th century, the Army recognized the need for doctors, nurses, hospitals, corpsmen and, in short, today's medical services. Immediately prior to World War I, the Army was headed by a chief of staff who was a physician, Leonard Wood (Fig. 2). He oversaw much of the transition of the Army medical service into a modern military medical system.

Why did it take so long, both here and in Europe? In all “civilized” countries, military medicine remained much worse than it should have been during the entire 19th century. There were three reasons. First, until the 20th century, most countries were run by aristocrats. Even in such ostensible democracies as England, they were the politicians, the generals, the senior military bureaucrats. Doctors were middle class, below the aristocracy. Simply put, nobody wanted to listen to them. This had been going on for centuries. Once, in the Middle Ages, physicians had a certain status as churchmen, but even that was incomplete. Barber-surgeons like Ambrose Paré were not only below the aristocracy, they were definitely lower class. Jean Larrey, a plebian, could succeed in only Revolutionary France. But such a man was looked down upon even in France, and would have been a second-class citizen anywhere else in Europe. Second, public health itself was poorly understood. Cities through the 19th century were, to put it bluntly, cesspools. Someone in the early 20th century commented that were it not for the automobile, city streets would have been three feet deep in horse manure. The countryside wasn’t much better, just less densely populated. Epidemics swept through Europe at regular intervals. Similar epidemics swept through military camps on a regular basis. Third, senior military officers were taught strategy and tactics. Logistics was a poor third. And the sort of logistics that concern caring for and evacuating the wounded is not a pleasant topic, nor one that would win prestige for an ambitious officer. Much less public health.

A famous comment made by a Civil War-era general to a physician who wanted to clean up the camp was, “Don’t worry. All Army camps smell that way.” There was a sort of pessimistic complacency. Senior officers knew that if they could keep down losses from disease, they would have more men to fight. But they didn't think anything could be done. Even if something could be done, they didn't want to do it themselves.

WORLD WAR I: BETTER CARE BUT SANITATION REMAINS A PROBLEM

The First World War was fought largely in the trenches of the Western Front. That’s not the full story, but it was and remains the public image. Trench conditions were miserable from a military standpoint. They were a disaster for public health. Sanitation was so bad that after a week or two in the trenches, troops had to be rotated back of the lines to be deloused, thoroughly cleaned, and provided with fresh clothing and equipment. Even so, disease was common, and wound contamination universal. Facilities were largely improvised, and soldiers were collected in the open to await care. All
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of this made wound care much more difficult (Figs. 3,4).

Even acknowledging all of the difficulties imposed by trench conditions, the casualty care system was still much better than in any previous war. Special military units, called ambulances, were charged with picking soldiers from the battlefield and transporting them to aid stations and then to field hospitals. So-called casualty clearing stations were used to collect the wounded and load them onto hospital trains. These were staffed with nurses and orderlies, and equipped to care for even difficult wounds. There were base hospitals and convalescent facilities both on the French coast and in England. As the American Army deployed to Europe in 1917-18, hospitals, doctors, nurses and ambulances went with them.

Wounds were usually contaminated with the mud of the trenches. For this reason, wounded soldiers were routinely given tetanus toxoid. Wound care emphasized debridement of devitalized tissue and thorough cleaning with antiseptic solution (Dakin’s solution, to be precise). Aseptic technique was (usually) used in operating rooms; better anesthesia was available. Bowel injuries could be routinely repaired. Intravenous fluids were available, as were blood transfusions (sometimes). Radiography had only been invented some 16 years before, but was deployed on the battlefields by 1914. As an index of how much things had changed, mortality following amputation had been 25% in the American Civil War, and was 5% in World War I. Deaths from wounds dropped, but deaths from disease dropped even further. Far fewer soldiers died of disease as a percentage of total deaths than ever before. And this was despite the influenza epidemic of 1918-19, which claimed many victims at the end of the war.

An example of the greatly improved casualty care was the experience of Robert Graves, a young British officer who would later become one of the premier writers of the century. His open chest injury was so severe that he was triaged to “expectant,” and his death reported in the London papers. Yet he survived the injury itself, empyema, and the resulting broncho-pleural fistula. After he was evacuated to England, he placed a notice in the papers to the effect that reports of his death had been much exaggerated.

The First World War claimed nine million soldiers and at least seven million civilian lives. Civilian estimates vary widely, and the true figure is probably unknowable. In 1918-20, over the course of the influenza epidemic (misnamed the Spanish flu), some 20 to 40 million people died. Half of all American soldier deaths from disease were due to influenza, many in the training camps in the United States itself. The extent to which the war caused the flu epidemic has been debated ever since. But the epidemic probably killed more people than the war.

POSTWAR THROUGH WORLD WAR II

Over the interwar years, and by World War II, many medical advances had been incorporated into military medicine—blood and plasma trans-

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MILITARY MEDICINE (continued)

Fusions, widespread use of intravenous fluids, antibiotics (but limited to penicillin and sulfonamides), endotracheal intubation, thoracic and vascular surgery, and the care of burn wounds. Plastic surgery had received a huge impetus from the World War I treatment of disfiguring wounds, and continued to advance before and during World War II. This war’s casualty lists were huge. There were some 20–25 million combatants killed, and 40–50 million civilians.

Both casualty care systems and public health continued to advance, but these were more a matter of degree than the much more dramatic improvements seen during World War I (Fig. 5). However, environments were equally challenging. Tropical environments were particularly difficult. It was a definitely mixed benefit that improved public health and sanitary measures enabled armies to operate in areas that were difficult even to live in. Tropical medicine began to assume a greater role in military medicine. And as always, at the point of the spear, casualties were high, resources limited and medical support difficult. The many amphibious operations during the war were extremely challenging. Even when the operation was supported with hospital ships, initial care and evacuation offshore was difficult.

RECOGNIZING PTSD

A major contribution of the 20th century was the widespread recognition and treatment of what we now call post-traumatic stress disorder, or PTSD. It has probably existed back into history. There are case reports from the Civil War, for example. During World War I, it was sometimes called “shell shock,” which probably included cases of actual brain damage. More often soldiers suffering from PTSD were diagnosed as “cowardice.” Soldiers were shot for it in the British, French, German, Austrian and Russian armies. As the war dragged on, it became better recognized, but its treatment varied widely. The Russians tried to treat near the front lines, sending the soldiers back to their units as early as feasible. We adopted that practice, and in fact, armies today still treat psychiatric casualties this way. What may seem heartless, actually proved to be the most effective way to treat PTSD and to prevent long-term sequelae. The recognition of PTSD as a psychiatric disease of war was not firmly established until World War II. They called it “combat fatigue.” But whatever they called it, they recognized it and treated it.

Both the Korean and Vietnam wars proved to be severe challenges to the medical system, the former for cold weather operations, and the latter for tropical and jungle warfare. The medical services gradually adapted to these challenges. By the time of the Vietnam war, and up to the present day, operations could be done in contained, air-conditioned operating theaters that were containerized or portable so as to be moved close to the battlefield (Fig. 6). Helicopter evacuation supplemented ground ambulances, and air transport replaced hospital trains. The system of progressive levels of casualty care has turned into doctrine, and remains the guiding principle for casualty care.

CHALLENGING THE MILITARY MEDICAL SERVICES IN NEW WAYS

Operations during the 40 years since Vietnam have produced far fewer casualties, yet have challenged the
military medical services in different ways. Small unit operations at greater and greater distances have increased reliance on medical corpsmen, who are now trained to at least the level of civilian Emergency Medical Technicians, and often higher. Casualty care and evacuation in a hostile civilian environment, always a problem in warfare, has been made more complex by opponents who refuse to respect the non-combatant status of medical facilities and personnel.

What can we say about military medicine today? Most of us focus on combat casualty care, as has been discussed over the past few paragraphs. And indeed, this is the primary focus of the system. We put huge resources into this, as well we should. The death rate for soldiers who survive long enough to reach medical care today is only a few percent. Overall casualty rates have decreased steadily since the Middle Ages, even though today’s weapons are far more powerful than those our ancestors fired off at one another.

Yet it is just as important to look at military medicine as a system of disease treatment and prevention. Deaths from disease have dropped far more than deaths from battle. In the Civil War, twice as many soldiers died of disease as from battle. In World War I, for the U.S. Army, the numbers were about equal. In World War II, only half as many, and in Vietnam, only one-fifth. These great improvements have come from the disciplines of what we now term “deployment medicine.” We have learned, often painfully, that these are as important to the overall health of the military forces as the system of casualty care. Perhaps, from a purely military standpoint, even more so.

A soldier ill from disease is removed from the combat strength as surely as one who is wounded. Yet, the illness is usually preventable. Deployment medicine is, in the Army’s unique jargon, a “force multiplier.”

As we watch combat operations on the nightly news, most of us look at these environments with horror and disgust. Everything looks destroyed, broken down. That’s true. In the first place, wars are not usually fought in vacation spots. Even when fighting occurs in pleasant places, they quickly become unpleasant places. Differences in climate aside, one war zone looks much like another. To maintain the health of armed forces, deployment medicine must address many issues: Adverse environments, with heat, dust, sand, wind and/or cold. Insect-borne diseases such as malaria, yellow fever and typhus. Food and waterborne diseases, such as cholera and dysentery. Epidemics, such as meningitis and hepatitis. Skin diseases. Parasitic diseases. And above all, the inevitable social breakdown, with civilian suffering, refugees, and the inevitable victimization of the weak by the strong.

There are five basic constraints which deployment medicine must overcome. Resources are always scarce. The environment is always adverse. Populations are usually hostile, if not deadly. Disease is always present, lurking in the corner. And finally, change itself is constant.

War is inhumane, and terrible. Yet, war has always been with us. The 20th century has been a century of war. Future generations will no doubt call it, “The Awful Twentieth Century.” But one of our greatest medical accomplishments of the last 100 years, among a host of other accomplishments, is the system of military medicine. Today’s military medicine combines combat casualty care with public health. As William Tecumseh Sherman put it, “War is all hell.” But we can take pride that we have done and are doing as much as humanly possible to reduce the horrors, and to save those who have been broken on the modern battlefield.

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