The AMEDD Historian

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Contents

Welcome to issue #36 of the *AMEDD Historian*! In the Army and in medicine, having the right tool for the task is vitally important. It is a statutory responsibility of The Surgeon General to equip the medical force, but it was a long-understood task even before it was codified. Although technical innovation in Army medicine did occur in previous centuries, this issue focuses on items that were brought about after World War I and the 20th Century. (It's okay, we have other newsletters for earlier items.)

World War I is a starting point, but many of the challenges are still experienced today. World War I demonstrated that Army medical personnel needed to train in field environments, and that existing equipment was often inadequate for the mission. Serving in mud-soaked trenches led to problem solving on how to keep bandages clean and how to efficiently evacuate casualties.

Advances in the medical field also had to be configured for operational use. As always there were points to consider. Is the item practical for battlefield use? Is it logistically feasible to transport? How many lives will this save? Oxygen tanks are quite hefty, but saved countless lives. (continued on page 24)

The Medical Department Equipment Laboratory

Lewis Barger, MEDCoE Historian

In December 1919 Surgeon General Merritte Ireland decided to establish a centralized agency to develop new equipment and improve upon existing equipment for use in Medical Department field units. During the World War equipping the Army (as it expanded from less than 130,000 active duty soldiers to over 4,000,000) took precedence over improving equipment, but with the war over Ireland was set on correcting some of the deficiencies that had been identified.

Staff initially looked for a place in the vicinity of Washington, D.C. to establish the Medical Department Equipment Laboratory. However, approval in May 1920 for an AMEDD field training school, made collocating the two organizations at Carlisle Barracks, PA an obvious choice. As an added bonus, the newly authorized Medical Field Service School (MFSS) was to be established on the site of the former Carlisle Indian Industrial School. The Indian School, in addition to providing an education in traditional subjects – reading, writing, arithmetic – also provided vocational training in manufacturing and farming. The Indian School had converted one of the old post stables to a wood- and iron- working shop, useful to the equipment lab for manufacturing and testing new equipment. The school's farms provided areas for testing equipment under field conditions. On 18 September 1920 the Surgeon General

directed the MFSS Commandant to organize the equipment lab as one of the departments of the school with the director of the laboratory as a member of the faculty.

During the war Captain John P. Fletcher, MC, had established a medical equipment depot at Louisville, Kentucky, including overseeing the marriage of automobile chassis and ambulance bodies prior to shipping fully assembled ambulances to units. Fletcher, a physician, became familiar with civilian manufacturers, manufacturing processes, contracting, and what today would be called program management. Additionally, Fletcher's assignment gave him visibility in the Surgeon General's Office so when the time came to appoint a director for the new equipment lab, Fletcher was chosen.

Army Chief of Staff Charles Summerall and Surgeon General Merritte Ireland examine a display of medical equipment sets designed by the Medical Department Equipment Laboratory on the National Mall in 1927. The laboratory's director, Major John Fletcher, looks on. U.S. Army photo..

Fletcher initially served at the MFSS both as the Director of the Laboratory and as the head of the Department of Equipment and Transportation. In this latter role, he was responsible for developing the curriculum for classes scheduled to begin the following summer. Fletcher was assisted in the equipment lab by a draftsman and would be assigned two military assistants the following year, but much of the burden of developing plans of instruction and setting up the equipment lab fell on his shoulders during that first nine months.

In June 1921, just as the school was beginning its first class, Fletcher was granted three months of sick leave for an unspecified disease. This condition was chronic and would take Fletcher away from his work periodically over the next decade. Fletcher's value, though, can be seen in his retention as director despite recurring bouts of illness amid AMEDD policy (from a 1922 downsizing) that mandated medical retirement of officers with chronic medical conditions. In November 1921 the equipment laboratory was moved out from under the school's Department of Equipment and Transportation and became a separate department of Carlisle Barracks.

By early 1922 the equipment lab was beginning to produce results. Fletcher and his assistants had been testing a new Stokes litter design and the Navy expressed interest in the test results – the first of many times that the equipment lab would benefit the sea service. One of the laboratory's first major projects was to redesign the first aid bandage that had been issued to all soldiers during the World War. That bandage had proven to have too little absorbent material and its packaging, a waterproof metal case equipped with a pull ring, was judged to require too much effort for some wounded soldiers to open in order to apply their own bandage. Fletcher constructed a new bandage with more absorbent material and designed a new case with a metal tape sealing its two halves which was easier to open. Progress was iterative. The case size couldn't grow, because it had to fit in the field pouch that attached to a soldier's harness. The new bandage with its added absorbent material packed too tightly in the case and wouldn't fall out of the case when opened. Absorbent material was reduced and the new case was tested again. Eventually an acceptable compromise was reached. The bandage wouldn't be produced in large numbers until

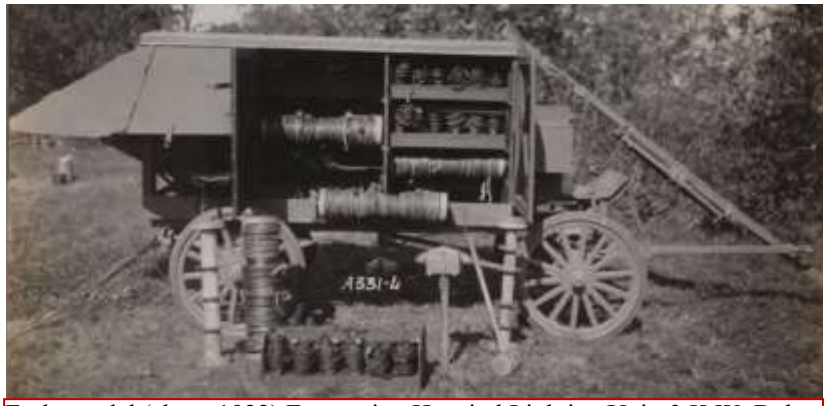
Carlisle Model First Aid Packet. AMEDD Museum.

the late 1930s – stocks of World War I bandages remained to be exhausted and the Great Depression would limit procurement during the 1930s – but the bandage which came to be known as the Carlisle bandage would be issued in the millions during World War II. (See newsletter No.7 for more about its WWII development.)

The equipment laboratory constantly had multiple projects running in parallel. While working on the Carlisle bandage, Fletcher was also designing a companion veterinary first aid packet, developing a power generation trailer for an evacuation hospital electrical lighting set, also under development, designing a new veterinary ambulance and a veterinary leading harness, and testing eleven models of hypodermic needle sterilizer, three of which were commercially available, eight of which had been designed in house, and all of which were eliminated from consideration because of impracticability. Other projects included a litter transporter, new field harnesses for medical soldiers, and a "combat wagon" for hauling both patients and supplies. Fletcher and his staff also had time to investigate some projects that weren't strictly medical. As an example, one in house development was the "fire grenade." By taking burned out light bulbs, removing the bases, filling the bulb with carbon tetrachloride, and resealing the bulb they created a fire suppressor which could be stored on racks in the laboratory and thrown on a fire to extinguish it. Evidently small fires were a routine hazard in a shop where open flames were common in addition to welding and soldering stations.

The matter of the power generation, distribution, and lighting set for evacuation hospitals provides a particularly illuminating example of the early work conducted by the Medical Department Equipment Laboratory. Fletcher had been directed to design it and produce 44 complete sets. Electrical lighting was just transitioning from a luxury to a necessity; in 1922 only about 30% of American homes were wired for electricity. Recalling that Fletcher was a physician, not an electrical engineer, his work developing this set is even more remarkable. Working with his two assistants and a draftsman they developed a power generation trailer mounting a generator and equipped with mounts to hold the associated wire, junction boxes and other equipment needed to distribute power to hospital lighting sets.

While the development work was interesting, the manufacturing was tedious and hampered by a lack of trained personnel. Fletcher complained to the Surgeon General's Office that "a manufacturing proposition of this size with soldier labor is a very difficult thing to do. We have been soldering lugs on cable for the last eight months and are only about two-thirds through now…Colonel Wolfe agreed with me that we should not be expected to do any more manufacturing."



Early model (about 1922) Evacuation Hospital Lighting Unit; 3 K.W. Delco gas-electric generator 110 V. direct current. Stimson Library collection.

The development work was not without its own pitfalls, though. One of the laboratory's organizational shortcomings was its tendency to develop items in a medical stovepipe without considering what other branches might have that could be useful or whether or not the Army supply system would be able to support the finished product. The generator trailer encountered opposition from the Quartermaster department, which was responsible for evaluating and purchasing transportation for the Army. The Quartermasters wanted to know why Fletcher had chosen a trailer chassis different from those already approved for Army use. They went on to request that "one of these units be turned over to the Experimental Section at Camp Holabird, Maryland, for study and test as to the proper chassis to be used for the unit." The Quartermasters had already tested the type of trailer Fletcher had used for his prototype and found it prone to breakage, and offered to test his so that "the Medical Department and the Quartermaster Corps will be in a position to have a record of the failures with which they will have to contend in the event of its adoption." Fletcher replied that while the Quartermasters had misidentified the chassis he had used, he didn't much care what the generator was mounted on: "Any chassis satisfactory to the Quartermaster Corps will probably accommodate the body if not the details of the body can be modi-

fied." Although this problem was easily rectified by switching to a different chassis, it was clear from the tone of the exchange that the Quartermaster Corps felt that Fletcher's work was encroaching on their dominion. A similar problem occurred the following year when the Quartermaster learned that Fletcher was modifying a GMC chassis from a World War I ambulance to develop an experimental ambulance design and informed him through channels that the Yellow Cab chassis was the approved truck chassis for use by the Army.

Despite increasing motorization, the laboratory continued to produce animal-drawn transportation models through the beginning of World War II. In an article published in 1942, Colonel Albert Dabney, third Director of the equipment lab, justified an animal-drawn cavalry ambulance developed in the preceding two years, saying, "as long as the Army maintains animal units, cavalry and pack, and especially animal-drawn ambulance units, it is incumbent upon the Medical Department of the Army to develop the best possible medical equipment and transport for such units." They also worked to improve upon the motorized ambulances that had served during the World War as well adapting existing vehicle chassis for the purpose and improving upon the design of the body to ensure they were heated, ventilated, and optimized for attending to patients in the ambulance as well as loading and unloading those patients.

Some projects like the combat wagon attempted to bridge the gap between the animal-powered and motorized Army. Capable of being drawn by a team of horses or pulled behind a truck, the combat wagon could carry twelve ambulatory patients, or six litter patients, or a mixture of litter and ambulatory patients. When not in use as an evacuation platform the trailer could be optimized for hauling medical supplies or unit equipment.

Combat wagon prototype configured to carry 12 ambulatory patients. Stimson Library collections.

Most of the equipment laboratory's work during the interwar years never went into full-scale production, largely because of a lack of funds or unwillingness to modernize in the midst of rapid technological change. The equipment laboratory's experimental designs did develop an important body of knowledge that was drawn upon when President Roosevelt declared a limited national emergency in September 1939 and the Armed Forces began to prepare for a possible war. The Carlisle bandage, with a few modifications to its nearly two decade old design, was placed into full production. Design Other subjects of research included: ambulances, tentage, medical equipment, and even packing cases.

With the beginning of World War II in Europe and the declaration of a national emergency in the United States the AMEDD had more resources for the equipment laboratory, increasing its personnel and funds. In the two years leading up to the attack on Pearl Harbor the equipment lab produced new prototypes for four-wheel drive ambulances, a bus ambulance for transporting patients in the Communication Zone (theater rear) and Zone of the Interior (continental United States), a cavalry ambulance, two different versions of a mobile surgical hospital, one built on semi-trailers and one using the body of the bus ambulance, and a mobile Army Medical Laboratory, also built on the bus chassis. The equipment laboratory also created designs for hospital train cars and equipment to modify Pullman cars and boxcars for patient transport. Over fifty smaller projects were also completed, running the gamut from a portable autoclave, to litter straps, soap impregnated paper wash cloths, to a 250-gallon water trailer.

With the increases in manpower and funding came administrative changes. The equipment laboratory submitted a list annually of projected projects and their anticipated cost to the Surgeon General's Office. A Medical Department Board was established in the Surgeon General's Office to consider and recommend projects for research and development, which also included requests from the Navy and other branches in the Army. The Surgeon General might elect to specify projects for inclusion in the list, and once completed, a prior-

itized list was forwarded to the Bureau of the Budget which published a final list of approved projects and the expenditures authorized for them.

During the war the laboratory continued to function, responding to requirements for modified equipment. The AMEDD established other investigative bodies as well to respond to requirements on many fronts in medicine, surgery, and nutrition as well as to investigate issues related to the newly-organized Armored Force. In addition to continuing to develop equipment for the Armed Forces, the equipment laboratory also examined captured enemy medical materiél and in early 1945 Colonel Earle Quinnell, the Director of the equipment laboratory, travelled to France to examine captured German medical supplies and equipment.

The war's end signaled the end of the equipment laboratory as it had existed for the previous quarter-century. Size constraints, environmental conditions, and other factors convinced the Surgeon General to relocate the MFSS from Carlisle Barracks to Fort Sam Houston, Texas. When the school departed Pennsylvania in February 1946 the equipment laboratory remained. Research and development organizations in the Army and Navy Medical Departments were being reorganized and on 21 June 1946 the Medical Department Equipment Laboratory was disbanded and its personnel and assets were designated the Laboratory and Shop Branch of the Engineering Development Division of the Army-Navy Medical Procurement Office. In November 1947 the Laboratory and Shop Branch was relocated to the newly established Army Medical Center at Fort Totten, New York. In 1957 the Laboratory and Shop Branch was reorganized to form the U.S. Army Medical Equipment Research and Development Laboratory. In 1962 it became a subordinate element of the U.S. Army Medical Research and Development Command and in September 1972 it was merged with the U.S. Army Medical Biomechanical Research Laboratory (the former Army Prosthetics Laboratory, see newsletter No. #4 for more) to form the Army Medical Bioengineering Research and Development Laboratory and relocated to Fort Detrick, Maryland. The following year the laboratory absorbed the U.S. Army Medical Environmental Engineering Unit. In November 1986 the organization was redesignated the U.S. Army Biomedical Research and Development Laboratory, and finally, in 1991, the organization was identified for closure by the Base Realignment and Closure Commission with the missions of medical materiél development, occupational health, and environmental quality missions transferred to other U.S. Army Medical Reearch and Development Command laboratories and to the U.S. Air Force's Armstrong Aerospace Medical Research Laboratory in Dayton, Ohio.

Between 1920 and 1946 the Medical Department Equipment Laboratory had five directors, none of whom served longer than Lieutenant Colonel John P. Fletcher. Fletcher was medically retired from his position as Director in 1930. Fletcher died in May 1941. In June 1943 John P. Fletcher U.S. Army General Hospital opened in Cambridge, Ohio, discharging its last patients in March 1946. Fletcher Memorial Park now occupies the site of the former hospital.

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Doctors and Gas Masks
Sanders Marble, PhD

In WWI the U.S. Army faced gas warfare for the first time, and some lines of responsibility were unclear. Once someone was gassed, they were clearly a Medical Department responsibility. But was gas defense a medical responsibility? Typically the Ordnance Department designed new equipment (in consultation with the users, e.g. Field Artillery), but the there was too much new equipment needed for the war and the usual process moved too slowly. Expertise around the government was mobilized (the Bureau of Mines had some experience), and the Army was willing to buy material from the British and French, who had been facing gas warfare for two years. But there might be better ideas available, and the Army was open to them. People in various places worked on the problems they saw rather than waiting for a solution from higher up.

Dr. Karl Connell (1878-1941) was talented surgeon and an inventive man. After graduating medical school from the College of Physicians and Surgeons in New York City in 1900, he specialized in surgery, becoming a surgical instructor at both Roosevelt Hospital and the College of Physicians and Surgeons. In civilian hospitals, anesthesia was often performed by inexperienced medical students. (The Army sometimes used doctors, sometimes nurses, and sometimes experienced enlisted men.) Also, there was no equipment to provide a steady flow of ether or chloroform, so during longer operations patients would have periods of deeper and shallower anesthesia, as more liquid anesthetic was dripped on the face-masks that were the most common method.

In 1913, Dr. Connell had the insight to adapt the flow-meter from a commercial gas supply, which would provide a reliable reading on the amount of anesthetic gas that was being provided. His new equipment could also cope with anesthetic gases that were becoming prevalent, such as nitrous oxide. Connell's work was good by itself, but was also part of a generation of flowmeters for anesthesia that improved inhalation anesthesia. Not just a surgeon and successful inventor but a businessman, Connell wrote similar articles for three medical journals to spread the word. Later, Connell added a re-breather circuit (thus re-using anesthetic rather than wasting it when it is exhaled), a carbon dioxide filter, and a way to mix in oxygen, so reliable level of anesthesia could be provided. Connell designed other anesthesia equipment, such as an airway, and would continue his work into the 1930s, ultimately receiving 10 patents.

In 1911, Connell had joined the 71st Regiment, New York National Guard. Although the United States was neutral when WWI broke out in August 1914, surgeons like Connell were interested in learning from the war wounds. American philanthropists funded some medical relief efforts in Europe, and a New York heiress, Mrs. Harry Payne Whitney, funded a small hospital. Connell was one of the four surgeons chosen, and they left in November 1914. They spent three months in France, part of the time in Paris and part of the time behind the French 6th Army front in a mobile hospital. More American clinicians were rotating over to Mrs. Whitney's hospital, but Connell wanted to see more of the war. He persuaded the U.S. Ambassador in Paris to make him a courier for the diplomatic pouch to Germany, traveling through neutral Switzerland. With a letter of introduction to the German army surgeon general he was allowed to tour both German and Austro-Hungarian medical facilities on the Western and Eastern fronts for several more months.

Connell Apparatus Company was one of only five suppliers of anesthesia equipment to the U.S. Army during WWI. This War-SP unit used Connell's second-generation flowmeter technology, could provide nitrous oxide, oxygen and ether anesthesia, and had instructions in French and English. Courtesy of the Wood Library-Museum of Anesthesiology, Schaumburg, Illinois.

He returned to the U.S. in 1915 and resumed his hospital duties until his National Guard unit was mobilized in June 1916, part of the response to Pancho Villa's raid on Columbus, N.M. While Regular Army units pursued Villa into Mexico, the Guardsmen trained and monitored the border in south Texas for about 90 days. Connell's service was uneventful, and he found time to create lantern slides to illustrate a talk about his European and Border experience.

He was active in the Preparedness Movement, advocating that America be ready for war in case one of the belligerents in WWI threatened U.S. interests. His activity landed him a position on the medical section of the Council of National Defense. There, he urged measures like stockpiling medical supplies and surgical equipment (which was mostly imported from Germany), as well as careful management of physicians so the civilian population was not under-served while doctors were not allowed to volunteer for non-medical service.

The U.S. declared war on 6 April, 1917, and Dr. Connell was mobilized on 11 July. He never served with his unit, but was detached to investigate an antiseptic, then was by-name ordered to France to work on gas defense. Initially, he was supposed to go to a British gas defense school, but after interviewing with COL Amos Fries, head of the Gas Service Section (later the Chemical Warfare Service) and talking about the anesthesia masks he had designed, he was shown the existing gas masks. He promptly suggested a substantially different model than any currently in use, with a metal face-plate and foam rubber to provide the face seal, with the filter on the back of the head. The rough drawings he produced in a few hours were impressive enough that he was ordered to Paris to make a prototype, and about three weeks later he wore it in a chamber filled with chlorine gas. There was minor leaking, but the design was good enough that he was sent to London (where more resources were available) to continue improvements. In a few weeks there were more samples, and he sent one to the American headquarters in France and another to Washington, D.C., for the War Department to examine. Connell's speed would do credit to modern rapid fielding efforts, and by sending prototypes both to the U.S. and HQ in France he avoided bottlenecking – or went around the chain of command, depending on your perspective.

Connell mask. Private collection.

The Connell Mask had some excellent features, including a way to reduce fogging of the eyepieces, and comfort features (neither nose-clip nor mouthpiece) that would make prolonged wear more comfortable while making it possible to communicate from within the mask. It also had a layer of paper in the filter that would remove particulates, such as sneezing agents, that passed through activated charcoal. However the foam rubber that provided the seal to the face was in short supply and the American Expeditionary Forces wanted to keep a simpler supply chain, so they purchased British masks. Connell was sent back to the U.S. where he worked with others to make what was called the 1919 American mask, an improvement on the British mask. For his work on gas masks, Connell received the Distinguished Service Medal.

Dr. Karl Connell receiving his Distinguished Service Medal in 1919. Courtesy U.S. Army Chemical Corps Museum.

Demobilized in 1919, Connell returned to civilian practice. He continued developing anesthesia equipment, ultimately selling his manufacturing company shortly before he died in 1941. Army development of gas masks went in different directions, and the Connell Mask is a what-if that shows us how flexibly the Army could react and how hard it can be to field new designs.

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The Development of Equipment for Blood Products
Grant Harward, PhD, ACHH

While every piece of medical equipment matters, there is nothing quite as directly lifesaving as the equipment that allows blood products to reach the wounded in the field increasing chances of survival during the "Golden Hour." The AMEDD's pioneering of new equipment resulted in the establishment of a tri-service blood program. Since World War II, the AMEDD has taken advantage of technological advancements to expand the Army's capability to deliver blood products in time to resuscitate the dying.

The history of delivering blood to save lives on the battlefield did not begin until relatively recently. The circulation of blood was discovered in 1616. Early experiments in transfusion often resulted in death due to insufficient knowledge of blood and the difficulty of the process. There was a renewal of interest in transfusion after 1818, but blood's physiology began to be better understood only after 1875. Finally, in 1900, the discovery and identification of blood groups paved the way for reliably transfusing blood on a mass scale. During World War I, armies dramatically expanded the use of blood to treat wounded as it soon became clear that blood was superior to other fluids in treating shock. Collecting and transporting blood represented significant challenges, however. Blood was relatively bulky, needed to be stored at cool temperatures, had a short shelf life, and was hard to transport as it was kept in vulnerable glass bottles. Consequently, blood was collected from the lightly wounded in hospitals near the front to treat the more seriously wounded. Shipping lifesaving blood across the ocean by boat was impossible. During the inter-war period, the OTSG began experimenting with extracting plasma from blood to be freeze dried as a solution.

The AMEDD relied on freeze dried plasma during World War II, but also pushed to develop new equipment to transport fresh whole blood to take advantage of advances in aircraft technology. In 1941, when the U.S. entered the war, blood only had a six to eight day window of use. Additionally, no overseas air lift existed. Consequently, the AMEDD used substitutes, especially freeze dried plasma that could be stored for months without needing to be refrigerated. Blood collected and distributed by blood banks near the front was put in glass bottles that were packed in marmite cans for delivery. In 1943, the OTSG requested a small, light, sturdy, and reliable refrigerator capable of being transported by air for delivering blood, but it proved impossible to meet these requirements. In late 1944, due to growing need on the battlefields of Europe, the AMEDD experimented with transporting unrefrigerated fresh whole blood by air across the Atlantic. By early 1945, a refrigerated container of reinforced cardboard, insulated with aluminum foil and cotton batting, and filled with ice that held 24 glass bottles of blood, weighting 105 pounds when packed, was introduced. A solution was also added to the blood as a preservative during the unrefrigerated flights. By the time the conflict ended later that year, the Army could envision transporting fresh whole blood collected in the U.S. by air to wherever it was called upon to fight its next war.

The AMEDD made key advances during the Korean War when it came to blood-related equipment. Perhaps the most important was the introduction of plastic bottles and bags for blood products. The work on this actually started a year before the conflict broke out in 1950. In the long run, plastic bags promised to be lighter, cheaper, and more durable – especially in the field. In the short term, military and civilian medical personnel resisted adopting the material for various reasons. Plastic bottles and bags came into general use in military hospitals in the U.S., however, they were not formally adopted in theater. An airlift for fresh blood was quickly organized, initially coming from Japan and other places in the Pacific, but soon from the U.S. too. The AMEDD began the conflict using the Bailey container that was based on the design used at the end of last war, but it proved difficult to handle. The OTSG introduced the Hollinger container as a replacement. This trunk-like plywood container insulated with Styrofoam and filled with ice kept 24 glass bottles of blood cool for 12 hours, but it was a heavy 133 pounds when full. The new equipment, expanded airlift capacity, and preference for fresh whole blood over freeze dried plasma meant that it now made sense to establish a permanent organization to manage the procurement, processing, and transport of blood products. The Armed Forces Blood Donor Program (AFBDP) was formed in 1951. Now, even after the war ended in 1953, the military could count

on having a reliable supply of blood products in any emergency.

Developments during the Korean War included plastic bags replacing the glass bottles used in WWII (left, center). Later, better insulation allowed smaller, lighter, boxes. The improved box weighed 47 pounds (against 100) and was 2.3 cubic feet instead of 8 cubic feet.
Images from *Blood Program in WWII* and *A History of the Army Blood Program.*

The AFBDP's peacetime research and development meant it was prepared for the Vietnam War. In 1962, responsibility over the AFBDP was delegated to the Army under the OTSG, which was re-named the Military Blood Program Agency (MBPA). In late 1965, as more American soldiers arrived in South Vietnam and fighting steadily became fiercer, resulting in more casualties, the MBPA introduced a revolutionary new container for shipping blood. The Collins container could hold the same 24 bottles of blood cooled by wet ice, but made almost entirely of a new Styrofoam it was more than half the size and weight, only 40 pounds when filled, than earlier containers. Moreover, it held the necessary temperature for 48 hours, or twice as long as before. Finally, the Collins container was cheap, costing just $1.40, in comparison the Hollinger container cost $98.60. This meant the MBPA could simply send a container to any forward area and forget about it instead of laboriously tracking it for reuse. Many a discarded Collins container had a second life as an ice chest for American and South Vietnamese troops. New preservation techniques extended the shelf life of fresh whole blood to 21 days. During the war, a reliable supply of whole blood was only a 30 minute helicopter ride from any field medical unit. The biggest problem in storing fresh whole blood was that ice machines had trouble coping with Southeast Asia's humid heat. In early 1968, the MBPA began using fresh whole blood 21 to 31 days old to produce fresh frozen plasma, which reduced bleeding problems after major surgeries or transfusions. Fresh frozen plasma, unlike freeze dried plasma, needed to be stored at very low temperatures before being thawed for use. The OTSG oversaw the development of a new deep freezer that was fielded by mid-1969. Dry ice was used in containers with fresh frozen plasma to keep them extra cold. Plastic bottles and bags steadily replaced glass bottles during the conflict. In 1972, the MBPA was re-named the Military Blood Program Office (MBPO) before the end of the Vietnam War a year later.

The MBPO faced fresh challenges in a new context as the Army transitioned to an all-volunteer force. In 1974, the MBPO made an agreement with the Food and Drug Administration to accredit military blood banks to collect and produce whole blood, red blood cells, and plasma – all of which could be exchanged with other military and even civilian medical facilities. Over the next decade, military hospitals transitioned fully from reusable glass bottles to single use plastic bags to store blood products as the material became even cheaper and more reliable. Civilian hospitals followed suit. In 1979, a new anticoagulant extended the shelf life of whole blood to 35 days, and then in 1983, other new additives increased it further to 42 days. The expense of managing a blood reserve that had to be replaced every month and a half caused the MBPO to turn to frozen red blood cells that could be stored for 10 years. This necessitated the procurement of ultra-low-temperature freezers and construction of new buildings to house them. Many Army blood specialists questioned the usefulness of frozen red blood cells for field operations in wartime, but this new blood product met the Army's limited demand in peacetime. In 1987, the MBPO was re-organized into the Armed Services Blood Program (ASBP). The ASBP introduced a bar code system to simplify the management of its inventory of blood products.

The Gulf War in 1990-1991 did not seriously test the ASBP and there was limited development of

new equipment for blood products during the post-Cold War drawdown. During the fighting in Iraq, the ASBP used fresh whole blood, liquid packed red blood cells, and fresh frozen plasma to treat the few casualties, often using Collins containers leftover from the Vietnam War to transport blood products. The ASBP created a depot for frozen red blood cells in Saudi Arabia, but fortunately this reserve was not needed. Icemakers struggled with the Middle East's extreme dry heat. The ASBP supported U.S. disaster relief and humanitarian operations over the next decade.

The terrorist attacks in 2001 resulted in the Army becoming embroiled in two long counterinsurgency campaigns in Afghanistan and Iraq that spurred the development of new equipment for blood. In 2002, the OTSG initiated research into a new container to carry blood farther onto the battlefield than ever before. The "Golden Hour" container used phase change materials (substances that transform from solid to liquid to gas at certain temperatures) instead of Styrofoam and ice to keep blood products chilled. This rugged and portable container, which could be worn on a sling, held up to four units of blood products and remained cool for 96 hours, double that of the Collins container. The "Golden Hour" container's success resulted in the introduction of a line of phase change material products over the next decade and a half that included smaller containers for medics, medium containers for helicopters, and bulk containers for aircraft. In addition to other blood products, the ASBP eventually used frozen red blood cells in Iraq. The ASBP also introduced rapid blood typing kits to verify a patient's blood type because misprints on dog tags occur 11% of the time. The new equipment, wide array of blood products, and rapid air evacuation saved numerous lives during the global war on terror.

Plastic bags (above) had become standard by the 1970s. The 'Golden Hour' container was developed after 2000 as a smaller, lighter container to go farther forward. DoD images.

Today, the AMEDD continues to support the efforts of the ASBP to provide blood products wherever they are needed around the globe. It is now focused on preparing for large-scale ground combat operations that will limit the Army's ability to evacuate wounded by helicopter within the "Golden Hour." In such a situation, the timely delivery of life-saving blood products will also be far more difficult, so research and development of new equipment to help solve this problem remains a priority .

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Plasma Package
Grant Harward, ACHH

Freeze dried plasma lasts longer than whole blood, and has fewer logistics considerations, making it more appealing to the Army in WWII. It took some time to develop the optimal type of package for freeze dried plasma.

With war engulfing Europe, the U.S. began to prepare in case it was pulled into the growing global conflict. The Army-Navy Subcommittee on Blood Substitutes decided the existing package (a cardboard box loosely packed with a glass vial of dried plasma, a glass bottle of distilled water, an IV needle, and rubber tubing) was too large and contents too prone to breakage. The Standard Army-Navy 250 cc.-Plasma Package had a vacuum-sealed glass bottle of plasma, a double-ended needle, and a clamp placed in a vacuum-sealed tin can, plus a glass bottle of distilled water, an IV injection set, and an air filter placed in a dry nitrogen-filled tin can. Both cans were packed into a waterproof fiberboard box, sealed with pressure-sensitive and waterproof tape. These plasma packages functioned beautifully, but they only contained a 250 cc. dose of plasma that wartime experience showed was too small and in November 1942, a larger package was designed. The Large Army-Navy 500 cc.-Plasma Package was basically the same as the previous version, but lengthening the package 2 inches allowed larger bottles and twice as much life-saving plasma. When production finally began in July 1943, medical personnel now considered 500 cc. of plasma as the minimum required when treating a patient for shock. Production of the smaller package tapered off as production of the larger one ramped up, but at the end of the conflict the Army still had both types stockpiled. During the Korean War, the Army quickly used up the few remaining standard plasma packages while procuring many more of the larger plasma packages. These were used until the Vietnam War when whole blood became more widely available due to developments in blood preservation and equipment.

Partial example of the Large Army-Navy 500 cc.-Plasma Package, with box and can for distilled water.
AMEDD Museum

The AMEDD Museum collection includes a partial example of the Large Army-Navy 500 cc.-Plasma Package . This one was produced in 1949 by Eli Lily in Indianapolis, Indiana. It has the two-piece outer box and the tin can that once contained the glass bottle of distilled water and other items.

Source

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The Perils of Good Ideas

Sanders Marble, PhD, ACHH

In the early 1960s, senior AMEDD leaders wanted better field hospitalization equipment. Canvas tents had been the state of the art for centuries, but newer materials were available, and could provide a better recovery environment for patients and a better working environment for hospital staff. Battlefield threats were also changing, with concerns about nuclear fallout and chemical weapons. In 1961 the Armed Service Medical Material Coordination Committee was considering improved hospital equipment (with Curtiss-Wright Corporation as contractor), but in June 1962 the ASMMCC was terminated and 94 tasks under development were transferred to the Army. Technical requirements were drafted, and Surgeon General Leonard Heaton got the 36th Evacuation Hospital to demonstrate field equipment to industry. The cited goals were logistical rather than improving patient care: reducing the weight and cube, greater mobility, and easier assembly and disassembly. Over 600 people from industry attended, and in June 1963 Garrett Corporation received a contract from Medical Research and Development Command to develop what was called Medical Unit Self-Contained, Transportable, or MUST.

WWII hospital tents had no floor and limited environmental control. U.S. Army photo.

The Garrett Corporation design was for rubberized fabric wards and connectors, linked to shipping containers that had the operating rooms, pharmacy, laboratory, X-ray, and central material services. The wards would be inflated by compressed air from portable jet turbines, and the turbines (called utility packs, or U-packs) would provide essentially unlimited power, hot water, suction, and both heating and cooling. Very early in development, additional goals were articulated: MUST would be not only logistically superior to existing equipment, it would improve patient care. The whole hospital would be easier to clean, reducing the risks of infections. Surgeons would have greatly improved working conditions, and not worry about extremes of heat and cold in the operating room. The U-packs could maintain overpressure, valuable against nuclear fallout, chemical or biological agents. While the hospital would be air-conditioned, the chief of logistics at OTSG emphasized "we are not trying to build an air conditioned officers' club here … Our purpose is built around the patient."

The "self-contained" in MUST referred to those containers, which could set up in 30 minutes. The Army had developed containers (CONEX, for CONtainer EXchange) in the early 1950s, and civilian shipping companies were using various sizes. The Army's version fit on the back of the M-35 2.5-ton truck, and that was a key requirement for the MUST containers. However, while the MUST containers fit on M-35s, they were not the same size as standard Army CONEXes.

Part of the improvements were inside the shelters. Much existing hospital equipment had been adapted from fixed-facility equipment, and was bulky, fragile, and/or heavy, and better equipment could be designed. Early MUST elements were focused on patient treatment and patient care. Such elements as food service and dentistry would be needed, but were penciled in for later. Prototypes of MUST equipment were available in March 1964. Testing began with normal reliability testing, such as railroad hump tests and road tests, and environmental tests, from -65º to 140º, with wind and rain. In late February 1965 MUST equipment was demonstrated to an invited public audience at Fort Sam Houston by the 24th Evacuation Hospital. By then, improving the quality of care had moved to the top of the list of justifications for MUST, although improving mobility was still third. A program manager (the AMEDD's first) was appointed in March 1965 to speed the process (full fielding was expected in 1967 or 1968), and Surgeon General Heaton saw Vietnam as an opportunity to field-test the new equipment. Vietnam was considered an urgent requirement and limited production of MUST was authorized before testing was complete.

The 45th MASH deployed in fall of 1966, including a 70-mile road march to Tay Ninh with no damage to equipment, something unlikely with canvas tentage and crates that were not containerized and had to be handled many times. Heavy rains delayed leveling the hospital site, and repeated mortar attacks not only killed the commander, they delayed opening by two days. The first patients arrived on 13 November, and in the first four months of action, the 45th saw 1,000 patients and performed over 500 major surgeries. Aside from the major equipment, there was much new gear inside: cabinets, desks, OR tables, surgical lights, and hospital beds had been redesigned, with less weight and cube. Some elements were substantially more practical, such as plastic trays that could go through the sterilizer and fit slots in the CMS instead of wooden trays having to be knocked together locally.

Several more MUST-equipped units deployed in 1967 (the 3d, 18th, and 22d MASHs), and the Navy bought two sets for hospitals supporting the Marines. Vietnam was an imperfect field test of MUST. Since the U.S. operated from fixed bases, and moved the patient rather than moving hospitals, it was hard to judge the mobility of MUST equipment. MUST units became like other hospitals, with fixed facilities built around the MUST equipment, for instance billets, messhalls, and latrines for hospital personnel, and the inflatable wards were revetted with sandbags to protect both the equipment and the personnel from fragments. Over time, all hospitals in Vietnam were air-conditioned. Once fixed facilities were completed for the MUST hospitals, the MUST gear was withdrawn. There were maintenance problems with the U-packs (which failed after an average of 244 operating hours, vs 560 expected), and spare parts were frequently a problem, probably because MUST was not standardized yet. Right away, the 45th needed extra maintenance personnel, some military and some contractor. The 44th Medical Brigade had to appoint a MUST program officer to track all the special items and personnel. In looking back on MUST units in Vietnam, MG Spurgeon Neel said MUST operated "with mixed success. … As good as MUST is, an air-conditioned fixed hospital is more suitable to Vietnam. … MUST should have been used to establish an immediate treatment facility in new areas of operations, then replaced by less expensive semi-permanent hospitals when the continuing need became apparent and construction support became available."

MUST tents went up easily, and provided clean, climate-controlled space for patient care. U.S. Army photos.

Back in the US, the AMEDD leadership was happy with MUST, even if troops had unflattering nick-

names for it. More modules were being developed. The Army also looked at adapting MUST for other medical elements, such as battalion aid stations and division clearing stations. In 1976, eighteen Active Component hospitals had at least some MUST equipment, and while there had been many minor upgrades and improvements, U-packs were still troublesome. The turbines gulped fuel, and reliability was so poor that a separate MOS for U-pack technician was recommended. In an era of tight Army budgets, MUST was noted as sufficiently expensive there were questions about viability of the program. Some modules were cancelled for being too heavy or too expensive, but the Army continued to field MUST as the best system it had.

By the early 1980s, DoD was planning common deployable hospital equipment for all the services "to increase the capabilities of the Military Services." Deployable Medical Systems (DEPMEDS) now had the AMEDD's first program manager. The project started in 1984, with fielding forecast for early 1987, but budget changes and inter-service approvals delayed fielding. The new containers met international standards and thus could use container ships – something that MUST could not. Cranes could not move MUST boxes, and they could not stack. DEPMEDS was first fielded to Reserve Component hospitals that were unequipped (equipping them expanded overall bed capability), but few equipment sets were fielded before 1990.

Thus the first hospitals that went to Saudi Arabia for Operation Desert Storm had MUST equipment that soon failed. Four early-deploying hospitals went with MUST and a Field Hospital deployed with General Purpose tentage and it was quickly determined these hospitals would not be able to handle the extreme environmental conditions of the Middle East: inside temperatures consistently exceeded 100 degrees. The MUST tents had dark exteriors, sand was abrading the U-packs (even locally improvised twenty-foot tall air intakes did not solve the problem), and the air the turbines were ingesting was too hot to be effectively cooled, plus they required large quantities of fuel. DEPMEDS sets were quickly pushed to Saudi Arabia from depots in Germany and Utah, and fielded to 35 hospitals. Even the DEPMEDS sets, however, were short some types of equipment—for example, the ICU in a DEPMEDS set had only one ventilator--so it was necessary to procure large quantities of commercial medical equipment off the shelf .

MUST improved the quality of care in deployed hospitals by controlling the environment and by improving the equipment used inside. Containerization had increased strategic mobility, since whole containers could be loaded instead of each individual chest or tent roll, and less handling meant less breakage. But the early generation of containers became non-standard, hampering mobility later. Another decision was immediately problematic, using turbines: fuel consumption was high but reliability disappointing. Using inflatable structures was also a problem. Yes, they could be quickly erected and collapsed, but puncture through enemy action was a foreseen problem. The very first requirements included automatic sealing of ruptured compartments, but there was no practical way to do that against multiple fragments, like the Viet Cong mortar shells that delayed the 45th MASH being operational. In Vietnam, units had improvised supports to the inflatable wards so they would not collapse if punctured, but that drove weight and cube back up.

By 2005 the AMEDD was looking at a new generation of deployable hospital equipment, with new shelters for the ORs and "air beam" tents instead of metal-framed ones. That was congruent with the Army Modernization Strategy of 2008, but will, of course, be as vulnerable as the MUST fabric.

The AMEDD will always have problems of deploying mobile and high-quality facilities. MUST showed some strengths and weaknesses of new equipment, and nobody was able to predict how containerization would develop. DEPMEDS was centrally managed among the services, which made sure things were coordinated but also slowing down what was accomplished.

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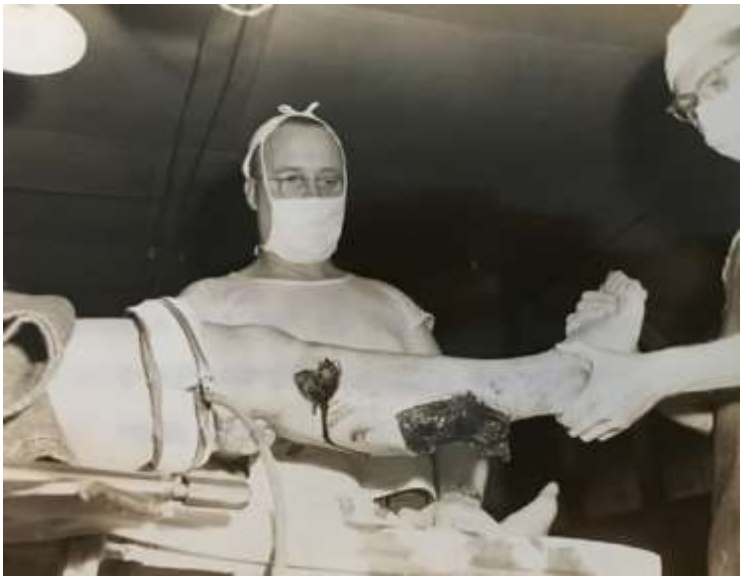
Holding Tight: the Potts Clamp and Vascular Surgery in the Korean War

Justin Barr, MD PhD

When Frank Spencer arrived in Korea in 1951 as a partially trained Navy surgeon, one of the first casualties he encountered was a young Marine shot through the femoral artery, the main blood vessel supplying the leg. Other doctors had decided to allow the leg to die before amputating the dead tissue, leaving that Marine a disabled amputee. While drastic, this method saved the wounded man's life, did not demand excessive time or prodigious skill, and in fact was standard of care throughout the US military in 1951, codified in War Department Technical Bulletin 147 (1945). But Spencer had uncommon exposure to the fledging field of vascular surgery, where doctors repaired arteries and sewed torn ones back together. Encountering this 18-year-old private, Spencer recalled, "Do I violate orders and fix the leg, or take the leg off when I could fix it and follow orders? I thought, well, I couldn't live with myself if I took a leg off and knew how to fix it." Excising the hole in the artery, he carefully placed tiny sutures on either side of the gap to appose the ends, restore blood flow through the vessel, and ultimately save the Marine's leg.



Lower extremity wound in PFC Jayy Sun, A Co, 194th Engineers, 22 April 1952. Wounds like this one were likely to cause vascular injuries that before 1952 surgeons treated by amputation. With the help of new technology like the Potts clamp, surgeons could repair the blood vessels and save the leg. U.S. Army photo via National Museum of Health and Medicine

Spencer was not the only surgeon brining innovative vascular surgery to Korean War battlefields. Physician-scientists had been publishing on various techniques to repair blood vessels since the late 19th Century, culminating in Alexis Carrel's 1902 paper describing the triangulation method. Transforming circular arteries into straight edges of a triangle facilitated the stitching and made the operation more feasible. This contribution garnered Carrel the 1912 Nobel Prize for surgery, bringing attention to both the man and the technique. Despite this recognition, vascular surgery remained rarely practiced, even in World Wars I and II when thousands of patients would have benefitted from its application. The reasons are complex and beyond the scope of this short article, but a combination of poor surgical training, lack of case volume, triage consideration, and inadequate supporting technology led to the infrequent practice of arterial repair. However, by the time of the Korean War surgeons like Spencer arrived, confident and capable of their vascular skills. Moreover, conditions of the war, with the 1951-53 stalemate, abundance of medical supply, and ready evacuation that whisked the wounded to surgical hospitals, enabled complex procedures such as arterial repair.

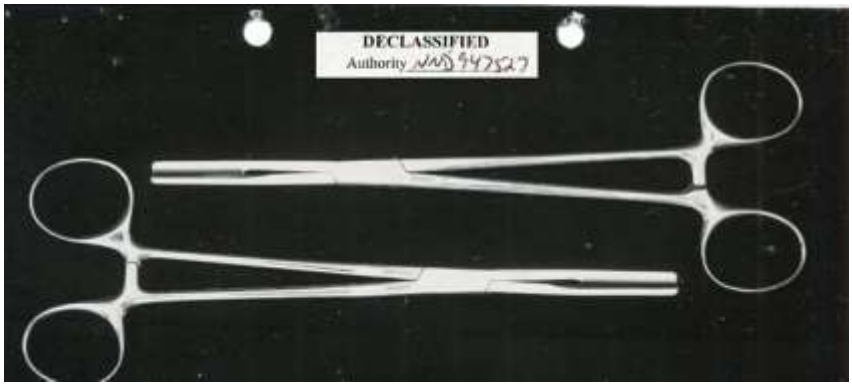
Sewing arteries together demanded more than just competent surgeons and better antibiotics: it also required vascular clamps. To operate on a blood vessel, you have to stop the blood coursing through it, lest the patient bleed to death during the course of the surgery. Surgeons typically apply clamps to arrest hemorrhage. Traditionally robust instruments, they would often macerate arteries and veins – which was acceptable if the goal was permanent hemostasis. But in the new field of vascular surgery, clamps had to stop blood from flowing while being gentle enough not to damage the fragile internal lining of the artery, so that after the operation undamaged blood vessels would continue to carry blood to distant tissue. The first commercially produced device to satisfy these demands was the Potts clamp, invented in 1948, just in time for the Korean War.

Blood vessel surgery had obviously progressed without the Potts clamp but required doctors to improvise and jury-rig solutions. Some used thin rubber tubing as de facto tourniquets around vessels. Others employed traditional clamps, although frequently met failure from the damage done to arterial walls. Otto Appel was a surgery resident in Ohio drafted in the army and deployed to the 8076th MASH in Korea. Like Spencer, he had some pre-war exposure to vascular surgery and refused to amputate limbs he knew he had the ability to save. Practicing first on North Korean prisoners, Appel mastered the techniques necessary to repair rent ves-

sels, establishing the 8067th MASH as the go-to vascular repair center. Yet he struggled to control blood flow during the operation. Ultimately, on a leave to Japan, he commissioned a local silversmith to fashion a suitable clamp and utilized that for the duration of his tour. But one-off homemade clamps were not a viable solution to what was becoming a more universal problem.

As vascular surgery expanded in Korea, so did the need for surgical equipment. Whereas when Appel and Spencer deployed to war when arterial repair was infrequent, the success of their interventions, as well as those by a team at Walter Reed Hospital, led to a change in practice 1952. No longer would surgeons preferentially ligate, or tie-off, bleeding vessels. Instead, they would attempt to repair them, or, if too severely damaged, replace them with vessels from a dead soldier. By late 1952, the Army established the goal of stationing a vascular-competent surgeon in each MASH hospital as well as in larger facilities such as the 11th Evacuation Hospital. The Navy similarly apportioned their resources. To train the surgeons, the Army created courses where incoming doctors would learn the principles of arterial repair before practicing their new skills on dogs. The military also recognized the importance of supplying these men with the proper instrumentation.

In 1948, John Potts invented the first commercial vascular clamps. Potts was a surgeon in Chicago who struggled to perform a PDA ligation. The procedure, invented by renowned pediatric surgeon Robert Gross in Boston, divided the patent ductus arteriosus, a congenital blood vessel that naturally involutes in most babies after birth but, when remaining open, can cause serious heart problems. To divide it, surgeons had to place a clamp on either side, cut in the middle, then sew closed the opening. "Without question," noted Potts, "the only obstacle to universal acceptance of division and suture of a ductus is the well-founded danger of uncontrollable hemorrhage due to slipping clamps." Teaming with machinist Brüno Richter, Potts developed an instrument to fill this need. It had fine teeth, pointed enough to grasp the vessel but too dull to puncture it. Richter compared the tooth density (40 teeth per inch) to a bed of nails on which a fakir sleeps, in that it distributed pressure among so many points that each individual tooth exerted minimal force on the artery wall. Narrow jaws provided surgeons more room to work. Most importantly, the clamp included a hub that blocked the interdigitation of the teeth, keeping them from pulverizing the artery. (figure 2) The Potts ductus clamps greatly facilitated not only ductus ligation but also peripheral arterial surgery and quickly came into high demand.



Pair of Potts clamps that deployed to Korea. National Archives.

Invented in 1948, the clamp did not appear – and was essentially unknown – in Korea until 1952. As a brand-new device fashioned for an esoteric operation performed exclusively in academic medical centers, the instrument was certainly not included on the TO&E of combat hospitals deploying to war. However, Edward Jahnke, a surgeon at Walter Reed Hospital, did have access to the technology and used it to great effect on wounded who had been evacuated to Washington DC. When Jahnke himself deployed to Korea in 1952, he brought a Potts clamp with. Other surgeons there immediately recognized the potential of this instrument and demanded one. However, the company that made it insisted that they were on back-order and that it would require some months before the clamp could be shipped to Korea. The commander of the surgical research team in Korea subsequently informed the manufacturer that they had two weeks to deliver six clamps before the Army broke the patent and produced their own; seven promptly materialized for military use. One went to each MASH unit and another to Spencer with the Marines. By the end of the war, the clamp appeared in standard surgical sets for MASH units.

The Potts clamp itself did not lead to arterial repair in the Korean War. Rather, its use both reflected and resulted in the expansion of such operations. Without early efforts to repair arteries in Korea, no need for the clamp would have existed. At the same time, the clamp so facilitated the steps of the surgery that the instrument catalyzed the dissemination of repair throughout Korea. In a 1953 journal article, Carl Hughes, a leading vascular surgeon in the war, wrote how "the Potts ductus…clamps contributed immensely to the success of the entire vascular surgery program." Its ability to simplify the operation certainly made it much easier

for the experts to train neophytes, helping distribute the operation widely to save the arms and legs of American wounded for the duration of the conflict.

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— 27 July 1775 —

New ACHH Archival Donations

Combat Medical Memorial photographs, documents, a/v material, artwork, and medallions belonging to LTC (Ret) Richard J. Berchin who was the Chairman of the Combat Medic Memorial Fund Committee.

Photographs and documents belonging to Captain Fern Green. CPT Green served as a Physical Therapist in the US Army and taught at the Physical Therapy School, Brooke General Hospital during World War II.

— 27 July 1775 —

The Shell Shock Serenaders broadcasting at Fitzsimons General Hospital. Fitzsimons had a radio station, KEUP, from 1926. Image courtesy National Library of Medicine.

The Evolution of the First Aid Packet
Chuck Franson and Paula Ussery, AMEDD Museum

Fabric bandages or field dressings have been used for thousands of years to bind wounds and injuries. The manufacture and issue of an individual soldier's bandage by the U.S. Army is, however, a very recent innovation in combat casualty care.

It was the germ theory of disease, accepted after the Civil War, that caused the production of a First Aid Packet. If germs were not a problem, a pocket handkerchief was good enough. Now there was a compelling reason to have a clean bandage.

The first war in which American soldiers carried official-issue First Aid Packets (or dressings), was the Spanish-American War. Although there was barely a month of combat, this war was America's first overseas combatant action and its effects on the Medical Department and the Army were far reaching. Due to the small size of the regular Army 125,000 volunteers were accepted for federal service. According to the report by the Chief Surgeon of the 5th Army Corps, 12,000 First Aid Packets containing antiseptic dressings were received at the medical supply depot in Tampa, Florida prior to embarkation for Cuba. Although some soldiers tossed them away as unnecessary while they marched through the hot steamy Cuban landscape, others soldiers utilized the new item to slow hemorrhage and protect wounds. An assistant surgeon with the 5th Corps stated "Words can hardly express the appreciation which the officers and men of the line have for the first-aid packets... The very small number of suppurating wounds can readily be accounted for by the prompt application of these dressings." Army Surgeon General George M. Sternberg estimated that 272,000 First Aid Packets had been distributed during this brief conflict.

In 1904 a pouch was introduced to provide a standard location on the soldier's equipment belt. This meant any soldier could find the bandage when the need arose, not unlike having a red tab on the tourniquet.

As a result of the medical observations during the Russo-Japanese War (1905) Army Surgeon General Robert O'Reilly requested the formation of a joint board of Army and Navy surgeons to revise and improve the First Aid Packet. The packet produced by this board was the one carried throughout WWI. The board wanted a simple dressing, easy to open, easy to apply without touching the compress that would touch the wound, and robust enough to withstand the rigors of field service.

The board created a dressing with a gauze pad (each 3.5" by 7") with an attached roll of gauze (4" by 84") to hold the pad to the wound; a safety pin was provided to hold the dressing to the uniform. The entire assembly was encased in waxed paper and 2 of the dressings were then sealed in a brass case. The brass case, 4" x 2.25" x 1" was carried in the First Aid Pouch on the cartridge belt or pistol belt of each soldier and officer. Directions were also included in the package.

The first massive field test of this new bandage was World War I. 12,400,000 First Aid Packets were produced in 1917, with Bauer & Black the majority contractor.

Since stopping to read instructions on the field of battle was impractical, the AMEDD procured "First Aid Packets for Instruction" for training soldiers. First introduced in 1911, these Instruction Packets were cheaper to produce than the issue packet and reusable. The contents were identical to the issue First Aid Packets, but were stored in a cardboard container. 400,000 First Aid Packets for Instruction were purchased by the AMEDD in 1917.

The WWI-era training bandage. AMEDD Museum.

As has been noted by Lew Barger, the Medical Department Equipment Laboratory reviewed the First Aid Packet after WWI. Among the changes made was eliminating the safety pin for attaching the bandage. Each bandage now had a "split-tail" so that the attachment device and bandage were combined. This compress and bandage continued to be issued through the 1980s. The Army trained individual soldiers to perform self-care or buddy care using the field dressing. Although effective, the problem remained that hemorrhage control was severely limited by how tightly the bandage tails could be wrapped, and by the availability of material for a field expedient tourniquet.

During operations in Bosnia in the late 1990s, NATO medics began using a new battle dressing, originally developed by an Israeli combat medic. In 2000, the Army Medical Department Center and School (now MEDCoE), began testing this new field dressing, consisting of a dressing attached to an elastic bandage that could be doubled back on itself to create a pressure dressing when applied correctly. The new bandage could easily applied one-handed, if needed. By 2001, it was being issued to Army Rangers, and by 2003 as the "Emergency Bandage," became part of the individual soldier's first aid equipment. It is available in 4", 6" and 8" widths. This marked the beginning of the evolution from a simple field dressing to a better means of responding to battlefield injuries.

The 'Israeli' dressing. AMEDD Museum.

In 2003, during Operation Iraqi Freedom troops were issued a more comprehensive "Individual First Aid Kit," which included an "Emergency Trauma Bandage" (sometimes referred to as "Israeli Bandage"), a tourniquet, adhesive tape, a small roll of gauze wrap, a nasopharyngeal airway to aid in breathing, and surgical gloves. The IFAK fit in a pouch with MOLLE clips.

Additionally in the 1980s, experiments were conducted to develop clotting agents for use on large deep freely bleeding wounds. Several commercial products were tested, based on more detailed study of clotting reactions, with some of the research funded by the Defense Advanced Projects Agency. Chitosan was tested, and zeolite granules and beads also tried; while these were better at stopping hemorrhage, they could cause burns. Eventually kaolin-coated gauze was used, which eliminated the exothermic reaction entirely. This 'combat gauze' could be packed into large wounds to help improve clotting, and achieve better hemostasis even when pressure could not be used on the wound.

Kaolin-impregnated gauze. AMEDD Museum.

Soldier input soon resulted in a number of improvements, and an updated "IFAK II" was soon developed. The updates include a smaller pouch, the inclusion of two tourniquets, combat gauze, a chest seal for decompressing a sucking chest wound, and a metal eye shield to protect the eye from damage during the dressing of facial wounds. A strap cutter is also included to help remove combat gear without excessive patient movement.

The first aid bandage has improved over the past 125 years. Improvement has not been steady, and funding routes have changed to include commercial-off-the-shelf procurement and DoD-funded research. Research continues, as the government tries to find a way to reduce morbidity and mortality from battlefield trauma.

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Fielding the Artificial Kidney

Dr. Willem Kolff designed the first artificial kidney in the mid-1940s. By the late 1940s a few were in use in the U.S., but they were highly experimental; the Army had one at Walter Reed, and was using it for research, and supporting external research through grants. Shortly after the Korean War started, a surgical research team went to Korea, and noted that 90% patients with acute renal failure were dying. Previously that had to be accepted, but now more was possible. The Army sent a small team from the Army Medical Service Graduate School (soon to be re-named Walter Reed Army Institute of Research) to the Peter Bent Brigham Hospital in Boston. They studied the state of the art for treatment rather than physiological research, then went to Korea with the Army's only Kolff-Brigham dialysis machine. Arriving in 1952, they treated battle casualties, serious injuries, and the sick, since Korean Hemorrhagic Fever (KHF) often caused kidney failure. The Brigham-Kolff proved reasonably robust (although certainly first-generation equipment) but the soldiers fitted a hand crank because they knew electric power was unreliable in the field. They also improvised, using an aircraft fuel tank and a cookstove to increase capability.

The 90% mortality fell into the 50s, and lower for KHF patients. The doctors published their data, and showed the viability of dialysis. Civilian hospitals adopted dialysis – if it worked on a battlefield, it could work for them. The Army shortly standardized a Field Renal Team to be ready for a next time. And the manufacturer of the Kolff-Brigham put the Army's results prominently in their marketing literature.

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Left: A staged photo of the Kolff-Brigham artificial kidney in use at Walter Reed.

Right: The artificial kidney in action in Korea, 1952. Courtesy National Museum of Health and Medicine

The Airmobile Operating Room

In the 1960s the Army acquired CH-54 heavy lift helicopters. They were extensively used in Vietnam to recover downed aircraft, but the 15th Medical Battalion of the 1st Cavalry Division (Airmobile) experimented with a surgical pod. In Vietnam, patients were typically moved to the hospital rather than hospitals being moved forward to the front lines. The airmobile surgical pod could be lifted to operate alongside the main support medical company, especially when weather conditions would delay helicopter evacuation. The surgical pod was used only twice; the division needed augmentation with surgeons for it to function, and that personnel process seldom meshed with the division's operational tempo. The one surgical pod was destroyed by fire in November 1966; the air cav had arranged to hand it over to the 2d Surgical Hospital since it was hardly useful as a mobile operating room.

Above: CH-54 Tarhe, courtesy U.S. Army Transportation Museum.
Right: The surgical pod at a landing zone. Courtesy National Museum of Health and Medicine.

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Armored Medical Treatment Vehicle

The Armored Medical Treatment Vehicle (AMTV) was a prototype vehicle developed under the Army's M4 Command and Control Vehicle (C2V) program. The M4 family of vehicles was developed in the mid-1990s, built on the M993 Carrier Vehicle for the M270 Multiple Launch Rocket System (MLRS), itself a variant of the M2 Bradley Fighting Vehicle chassis. The AMTV and its companion vehicle, the Armored Medical Evacuation Vehicle (AMEV) were intended to replace the M577 battalion aid station treatment vehicle and the M113 ambulance, respectively.

Lessons learned during Operation Desert Storm led the Army to develop the M4 C2V family of vehicles for the Force XXI Army Warfighting Experiment. The M4 C2V included onboard generators, a 579 cubic foot crew compartment with a biological-chemical overpressure protection system and an environmental cooling unit. The AMTV had a central position for treating a litter patient inside the vehicle while on the move with room for medical treatment providers to work on either side of the litter. The AMTV could carry four litter patients in addition to the medical crew when the vehicle displaced to maintain contact with the supported unit.

Above: The AMTV in field tests.
Below: The AMTV on display outside the AMEDD Museum. U.S. Army photos.

The M4 C2V development program was canceled in 1999 when the Army shifted to a lighter, expeditionary Stryker-based platform resulting in the development of the M1133 Stryker Medical Evacuation Vehicle. The Stryker itself was intended only as an interim solution until the Future Combat System was fielded, but that – like the M4 series – was cancelled.

Research and testing undergird new equipment, leading to specialized test gear. The JUH-60 (tail number 88-26069), called Research-69 was specifically designed by Sikorsky for in-fight aeromedical data collection for the US Army Aeromedical Research Laboratory (USAARL). The aircraft possessed a unique wiring harness permitting aircraft data recording from a discrete bus relay system. The aircraft data, merged with human physiological performance data, was used to produce empirical data for USAARLs in-flight investigations. Flight Systems Branch of USAARL and Research 69 had impacts far outside USAARL's walls; collaborative organizations have included Army and defense agencies, academia, and industry. Pilots were also trained in aeromedical factors research techniques.

Research-69 and her crews produced hundreds of technical reports, and airworthiness certifications in support of the MEDEVAC community for over 30 years, and discovered innovative technologies such as the Tactile Situational Awareness System, and the Noise Immune Stethoscope. Other pivotal studies include stroboscopic motion sickness prevention, spatial disorientation prevention, Army aircraft noise level measurement, patient isolation units, wound vacuums, and numerous onboard rescue devices and life-saving equipment, such as defibrillators, the first telemedicine devices, parachute systems, unmanned aerial capabilities, situational awareness tools, and newest night vision devices and helmet mounted display that will be fielded in future generation helicopters.

Developing New TBI Diagnostics
Charles Franson, AMEDD Museum

In modern warfare, great strides have been made in the care of conventional trauma. The introduction of clotting agents, the introduction of improved tourniquets and other innovations have increased the survivability of injuries previously deemed mortal. Better body armor and improved vehicle armor have altered the profile of modern injuries; however, the extremities and head remain rather vulnerable. Concussion and Traumatic Brain Injuries (TBI) became common in counterinsurgency warfare. In one recent study, 33% of all patients with combat-related injuries and 60% of the patients with blast-related injuries seen at Walter Reed National Military Medical Center had sustained a TBI.

The brain is especially vulnerable. Although it is protected by the skull and helmet, rapid deceleration trauma, such as found in a vehicle accident, or an explosion, may cause the brain to slosh back and forth in the cranial vault. Such injuries may also occur secondary to a blast. The resulting insult may rupture capillaries, tear brain tissue and generally wreak havoc. Timely intervention is required to minimize the lasting effects of neurotrauma. The Army has conducted field trials of a number of devices, looking for better diagnosis of TBI to start treatment sooner.

Standardized concussion assessments using questions related to orientation, signs such as headache, nausea, dizziness etc. proved useful in many cases. However, recent innovations have shown even greater promise in diagnosing brain injuries based on correlation between the tracking of eye movements and neurological impairment.

The AMEDD Museum has been given a prototype (circa 2012) EYE-SYNC portable neurodiagnostic device. It was developed by a private company, but with DoD funding, to identify potential cases of TBI/concussion at a Role 2 or 3 facility. The unit is fully portable, and is fitted in a case the size of a piece of carry-on luggage, weighing approximately 20 pounds. The components are cradled in foam, and are designed for rugged durability.

The patient's head is placed in a hooded set of goggles, similar to Virtual Reality glasses, and images are presented. Cameras, electronics, and optical components track the patient's eye movements, and the data is fed into a laptop computer, where a program quantifies how well a patient's eyes can follow and synthesize a visual target, and the information is presented to the provider for interpretation and diagnosis. The success of the device, has led to an even smaller, more portable unit using a set of VR goggles and a tablet.

In the near future, forward personnel may be able to send data via telemedicine to a neurology team in order to initiate treatment while the patient is still in the field.

Left: A 2012 prototype Eye-Sync. AMEDD Museum
Above: The 2021 second generation Eye-Sync. SyncThink Inc.

(continued from front page)

Back to the right tool for the task. Trials and experiments test prototype equipment and there are failures, but also successes. In other cases rigorous experiments can only go so far. It is all part of the process for the AMEDD working to bring best possible equipment to the field.

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We are seeking contributions! We believe variety is the way to attract a variety of audiences, so we can use:

- Photos of historical interest, with an explanatory caption
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Material can be submitted to **usarmy.jbsa.medical-coe.mbx.hq-medcom-office-of-medical-history@army.mil** Please contact us about technical specifications.

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