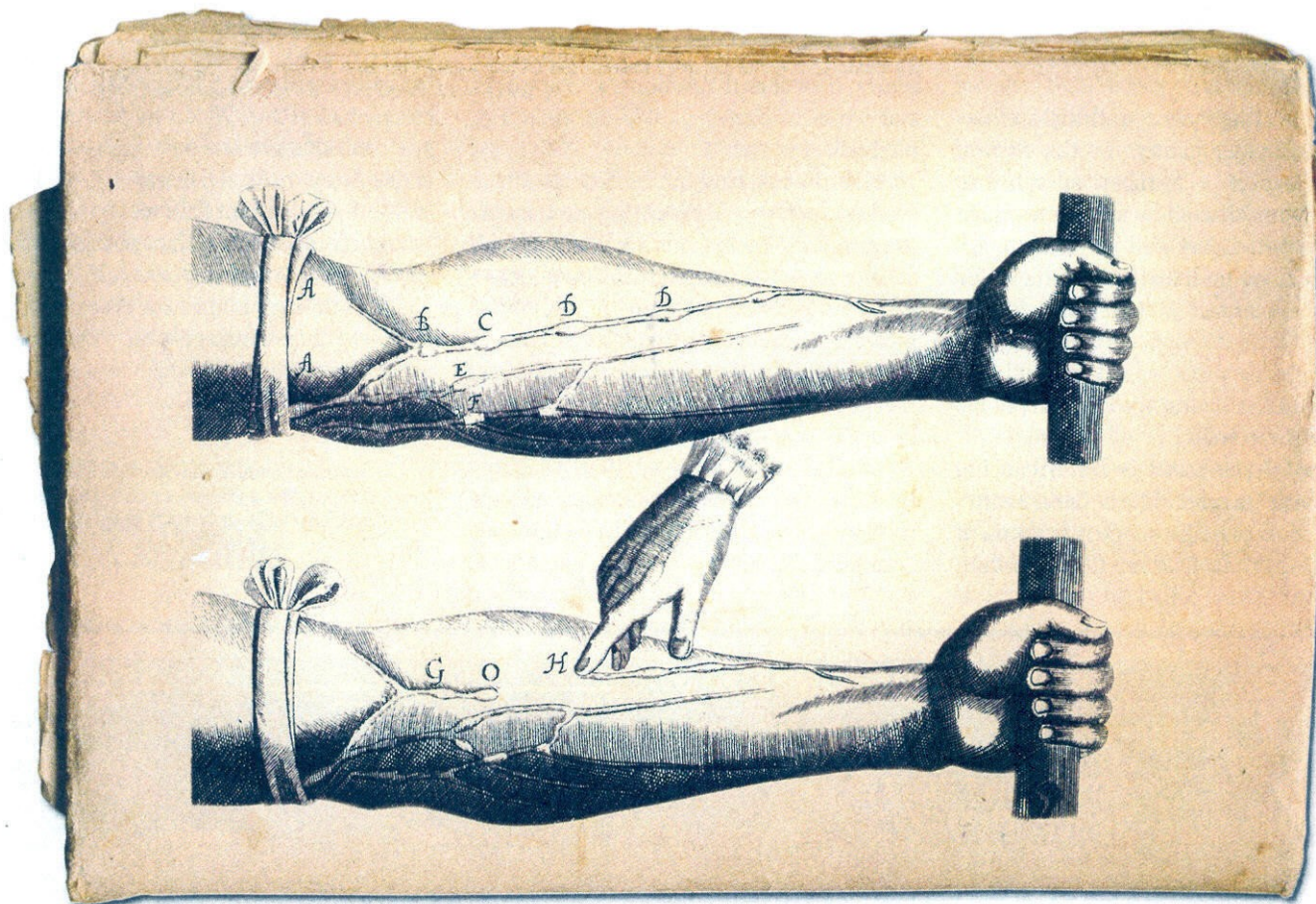


Tighten Up

TOURNIQUET TECHNOLOGY ON TODAY'S BATTLEFIELD.

By JOHN F. KRAGH, JR., M.D.



Tourniquets have become common on today's battlefield as they are standard issue to individual deploying soldiers. However, before the U.S. Army surgeon general recommended such issue in March 2005, tourniquets were mostly improvised devices and seldom seen. Although field tourniquets were popular at the beginning of such wars as the American Civil War, World War I and the Spanish Civil War, they later fell out of favor. Their intended use, of course, was to save lives from exsanguination, but senior surgeons, observing the morbidities with inappropriate use, saw little lifesaving benefit. For example, in 1975 the second edition of the *Emergency War Surgery* handbook said that tourniquets should be a measure of last resort to control bleeding. Yet the leading cause of preventable death on the battlefield in the Vietnam War was limb exsanguination for which no good fix existed.


The knowledge of tourniquets had advanced substantially after World War I due to a Medical Research Council initiative and the study of elective limb surgery where tourniquets are used routinely. In 1984 a Vietnam casualty analysis found that limb exsanguination was the leading preventable cause of death on the battlefield. Then the Israelis in 1985 switched to a policy that promoted tourniquet use as a result of their experiences in the conflicts of the 1970s and early 1980s. U.S. special operations forces also adopted such a policy over a decade later after consultation with tactical combat casualty care providers. Better commercial tourniquets became available as market needs were seen. Thus, the scientific advancements of tourniquet use in surgery, coupled with refined first aid doctrine and improved technological tourniquet design, provided another opportunity for the military to try to save lives on the battlefield by re-addressing the tourniquet controversy.

Prior to the U.S. military re-adoption of a policy of encouraging emergency tourniquet use, few studies were published on this measure of last resort. No one could prove that tourniquets had a lifesaving capacity, let alone offer instruction on how best to use them. However, since the U.S. military re-adoption of emergency tourniquets, results have become available and several studies measuring effectiveness and safety have been published. These studies, mostly from combat support hospitals in Baghdad, have found that emergency tourniquet use to stop bleeding saves lives and carries little risk of morbidities. No limbs were lost due to tourniquet use, and there were few clots, nerve palsies, or tourniquet malfunctions. Clearly visible in the hundreds of patients studied, benefits were lifesaving and benefits far outweighed risks.

These studies have also shown which devices worked best in prehospital and hospital settings, which ones failed, and when and how tourniquets are best used. The devices that were most effective in

the war hospital experience paralleled the laboratory results of tourniquet testing in normal volunteers. Specifically, the Combat Application Tourniquet (CAT) was the most effective field tourniquet used in the Baghdad casualties. (The CAT was also the most frequently used as it was recommended and fielded for individual warrior use.) The laboratory testing also recommended the Special Operations Forces Tactical Tourniquet (SOFTT) for fielding when the CAT was unavailable. The SOFTT was seen less frequently in Baghdad and was second most effective of the field tourniquets.

However, of all available tourniquets, the most effective in combat support hospitals and laboratory studies was the Emergency Medical Tourniquet (EMT), a hospital tourniquet designed for emergency use. The EMT pneumatic design was also recommended in the laboratory testing for hospital, clinic, and ambulance use. But because the EMT is more fragile, expensive and complex than the strap



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Marine Corps Lance Corporal Martinez, Golf Company, 2nd Battalion 3rd Marine Regiment, pretends to apply a tourniquet during squad competitions in preparation for the Super Squad Competition.

CAT and SOFTT tourniquets, it has not been recommended for individual warrior fielding.

Effectiveness was positively associated with tourniquet width and negatively associated with limb girth in both the laboratory and hospital, findings that were concordant with surgical tourniquet knowledge. Side-by-side tourniquet use widens the tourniquet effect and is the most practical way of stopping bleeding if one tourniquet is ineffective. From orthopaedic studies and animal research, it is known that over-tightening does not help improve effectiveness after an under tourniquet pressure of 300 millimeters of mercury (mm Hg) is reached, and over-tightening past 500 mm Hg risks nerve and tissue damage, and this over-tightening problem has happened with tourniquets of pneumatic, ratchet, and strap and windlass designs.

In the Baghdad studies, the thigh was where the side-by-side use was most needed and useful. Third tourniquets were rarely needed. Improvised tourniquets were often ineffective, but they were better than no tourniquet at all. The clinical results favor

the use of well-designed tourniquets, and improvised tourniquets are recommended only when no better tourniquet is available.

All tourniquets showed wear and tear, and when manufacturers were interested, the results of the studies helped them improve their designs. For example, in 2006, worn EMTs were mailed to the maker, redesigned, remanufactured and mailed to the Baghdad emergency room within seven weeks. CATs were also improved, and a third design of the EMT arrived in Baghdad in August 2007. Field tourniquets, which are single use items, have been reused after cleaning when serviceable.

CONTROVERSY AND SUCCESS

The story of emergency tourniquets is one of controversy and success. The story is still being written, but the hard, complex work of synthesizing historical performance, training, doctrine, research and development has been fruitful. Prior to the Baghdad studies, the Thomas splint was the only first aid device evidenced to save lives of limb-injured patients. The World War I Thomas splint for open femur fractures was life saving by controlling hemorrhage. The tourniquet's lifesaving capacity is similar to the Thomas splint, and evidencing such lifesaving capacity in first aid research is a once in a century finding in limb-injured patients. Readers who are interested in first aid should look for more articles to read soon on emergency tourniquets, a success story of military medical technology of the first rank. ★

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