

# A Balanced Approach to Tourniquet Use: Lessons Learned and Relearned

COL David R Welling, USAF MC (RET), MD, FACS, FASCRS, COL David G Burris, USA MC, MD, FACS, BRIG GEN John E Hutton, USA MC (RET), MD, FACS, Stanley L Minken, MD, FACS, COL Norman M Rich, USA MC (RET), MD, FACS

Recent military conflict has created a multitude of extremity wounds, and their proper treatment has been debated. The question has been asked whether or not we should apply tourniquets to these wounds if they are hemorrhaging. The express purpose of such tourniquets is to stop arterial inflow and prevent hemorrhage. This review of the use of tourniquets was stimulated by these current events and heightened interest in this ancient device. Historical data are reviewed and comments about modern-day tourniquet use are presented.

## HISTORY OF THE MILITARY AND CIVILIAN USE OF TOURNIQUETS

### Early use

The history of the use of tourniquets in ancient times is very much tied to the history of amputations. Several early surgeons found that amputations could be performed without undue blood loss with application of the tourniquet. It is somewhat unclear who was the first to use a tourniquet. Laffin believes it was a surgeon named Morel, who, during the battle of Flanders in 1674, began using a crude form of the tourniquet. "A rod was placed above the amputation spot against the main artery, and a band secured to the limb and pressed so tightly to the bone that the pulse below the ligature ceased to beat; the amputation was then performed. Since the blood vessels were compressed by the pressure of the band and bled very little, they could be sutured without undue haste. This was the first use of a tourniquet."<sup>1</sup>

### Competing Interests Declared: None.

This article represents the personal viewpoint of the authors and cannot be construed as a statement of official United States Department of Defense or the Uniformed Services University policy.

Received July 22, 2005; Revised February 22, 2006; Accepted February 27, 2006.

From the Norman M Rich Department of Surgery, Uniformed Services University of the Health Sciences, Bethesda, MD.

Correspondence address: Colonel David R Welling, USAF MC (Ret), Department of Surgery, Uniformed Services University of the Health Sciences, 4301 Jones Bridge Rd, Bethesda, MD 20814-4799.

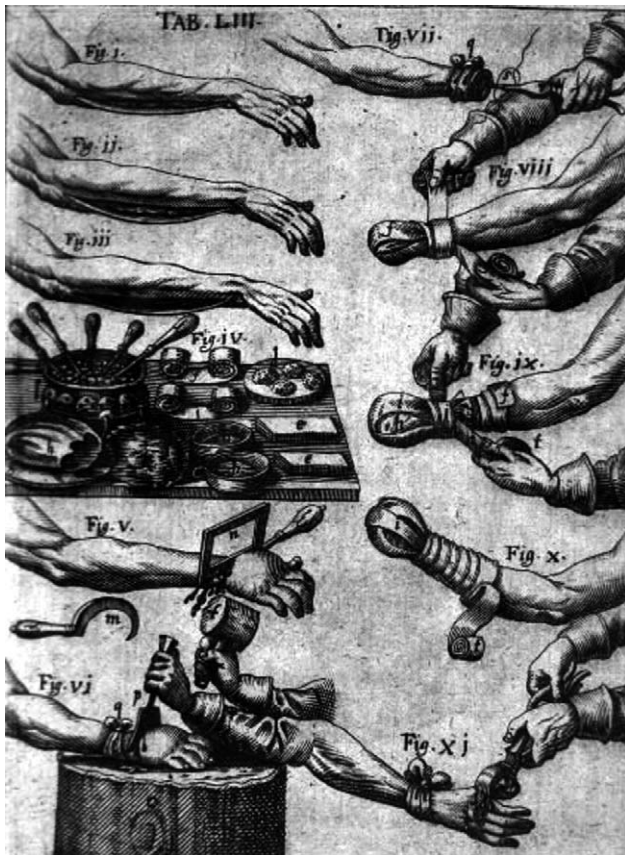
According to Wangensteen and Wangensteen,<sup>2</sup> other early surgeons were known to have used some sort of tight band during amputation. Guy de Chauliac would wrap a ". . . tight band above and below the site of amputation to reduce pain and minimize bleeding by compressing the soft tissues against the bone." Wangensteen and Wangensteen describe others as well: "In the sixteenth century, Leonardo Botallo advised putting three bands around a major extremity to be removed, amputating between the lower two; Fabricius tightened a band above the site of amputation, twisting it with a stick to control bleeding." Johannes Scultetus of Ulm depicted a screw compressor in his famous 17<sup>th</sup>-century illustrated surgery (Fig. 1). Petit's tourniquet (1718, 1731) presented an advantage over Scultetus's screw compressor in that it provided for fixation of the tourniquet on the lower abdomen. Thus, the instrument was prevented from slipping and amputation could be done at a higher level<sup>2</sup> (Fig. 2). Many such reports about tourniquets, until the end of the 19<sup>th</sup> century, were laudatory, usually failing to mention possible risks.

### Civil War

The death of General Albert Sidney Johnston, at Shiloh, Tennessee, illustrated that at least some of the soldiers had been issued tourniquets. Johnston was a Confederate officer who had rallied the troops to attack the stubborn, unyielding Union soldiers near the Peach Orchard. He led the charge. He was hit in the right popliteal artery with a stray minié bullet. This serious wound he apparently ignored, despite the resultant massive hemorrhage. He exsanguinated, but with a tourniquet still in his pocket.<sup>3</sup>

### World War I

World War I produced countless wounds, and substantially improved our knowledge about the positives and negatives of wound care. It was during this war that potential complications of the use of the tourniquet were brought into sharp focus. Because many casualties had

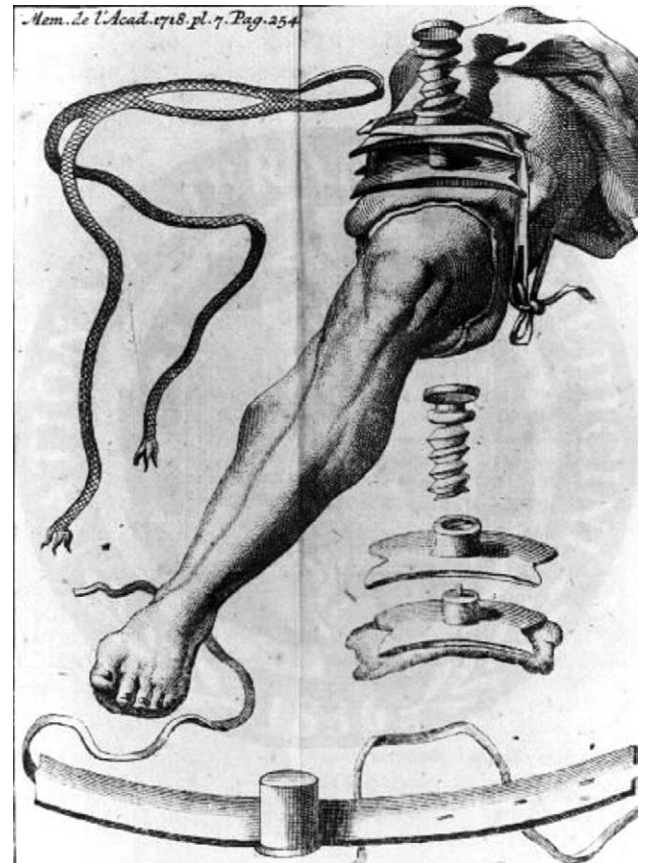


**Figure 1.** This engraving from Scultetus clearly shows the use of tourniquets during amputations. (Reprinted from: Scultetus, Johannes Francofurti, Sumptibus viduae Joan. Gerlini, bibliop. Ulm, typis Joannis Gerlini, 1666 *Armamentarium chirurgicum bipartitum*. Courtesy of National Library of Medicine.)

to wait in “No Man’s Land” until they could be removed after dark and then be transported to field hospitals for care, there was often a considerable delay from time of wounding and placement of tourniquets, until final treatment, leading to catastrophic end results.

Tuffier, who was “Consulting Surgeon to the French Armies in the Field” and who was a great surgeon of his day, wrote a detailed article in the middle of World War I that describes contemporary French surgical care. In this article, he expressed dissatisfaction with the use of tourniquets in general. His surgeons were trained to use ligatures to stop bleeding. “The tourniquet is sometimes utilized under circumstances where it is actually impossible to apply a ligature, but it has caused disasters. As soon as a tourniquet is seen in an ambulance it [the tourniquet] should be taken away.”<sup>4</sup>

The US Government published a reprint of the Official British manual, entitled *Injuries and Diseases of War*



**Figure 2.** This engraving from Petit illustrates his version of the tourniquet. (From Petit M. Paris, 1718 *Memoires de l'Academie des Sciences*. “D’un nouvel instrument de chirurgie.” Courtesy of National Library of Medicine.)

in 1918. In this small book, one finds a rather pessimistic view of tourniquets and their usefulness. The section on tourniquets begins with this statement: “The systematic use of the elastic tourniquet cannot be too severely condemned. The employment of it, except as a temporary measure during an operation, usually indicates that the person using it is quite ignorant both of how to stop bleeding properly and also of the danger to life and limb caused by the tourniquet . . . If an orderly has applied a tourniquet, it is the duty of the medical officer who first sees the patient to remove it at once, and to examine the limb so as to ascertain whether there is any bleeding at all, and if there is, to use proper measures for its arrest.” The manual goes on to say that there are real dangers in the application of tourniquets, including intense pain, promotion of anaerobic infections, and loss of limb. The reader is exhorted to never let a patient leave the field ambulance with a tourniquet on a limb.<sup>5</sup>

Keen,<sup>6</sup> in *The Treatment of War Wounds*, briefly mentioned tourniquets. He had served in the Civil War; had worked under the great surgeon, Letterman; and perhaps had seen tourniquets applied in the Civil War. His book described his World War I experience. He simply said: “At the first-aid station, and possibly at the dressing station, only urgent operations should be done, especially, eg, for the arrest of hemorrhage. No patient should ever be forwarded from there with a tourniquet still applied on a limb.”

The lessons of World War I were also detailed in the *Handbook for the Medical Soldier* by Tuttle.<sup>7</sup> He emphasized using “pressure points” to stop arterial bleeding, using underlying bone as a platform against which to push to occlude the artery. This method allows enough time for a second rescuer to apply a tourniquet.

The principle of all tourniquets is a pad over the artery, to bring the pressure on the artery and take it off the veins, a band around the limb and over the pad, and some means of tightening the band. There are a number of special tourniquets; for field use we provide a Robinson type, which is much like an ordinary web belt, but has an ingenious kind of buckle for holding the webbing at any point. If one of these is not at hand a suitable one must be improvised; an excellent tourniquet may be improvised with a rubber bandage; a number of turns are made about the limb and the rolled portion of the bandage then placed under the last turn in such a position as to press directly on the artery. . . . The most common improvised tourniquet is the Spanish windlass; in this arrangement any rounded, smooth, hard object, such as a stone, a cork, or a roller bandage, is used as a compress; for the band a handkerchief, a suspender, a waist-belt, a bandage, or anything of the sort may be used; to tighten up the band a stick or bayonet-sabbard or something of the kind is passed under the band and twisted until the bleeding ceases, when the ends of the stick are tied to the limb to prevent the band from becoming untwisted. (See Fig. 3.)

Tuttle goes on to give some good advice about the applications of tourniquets: “1. Never cover over or bandage a tourniquet. 2. Write plainly on the emergency medical tag the word ‘tourniquet.’ 3. If the injured man is conscious, he should be instructed to tell every medical officer with whom he comes in contact that he has a tourniquet on. 4. Lastly, remember, if a tourniquet is left on a wound for six hours the limb will surely die.”<sup>7</sup>



**Figure 3.** This picture illustrates the “Spanish windlass,” a popular tourniquet of World War I. (From Tuttle AD. *Handbook for the medical soldier*. New York: William Wood and Co; 1927:315, with permission.)

The lesson from World War I was that the benefit of a tourniquet was not without potential cost. Properly placed tourniquets left in place for long periods led to loss of the distal limb. Apparently, with the long time to final care that often occurred during that war, the surgeons thought that some limbs could have been saved if the tourniquet had not been used, leading to the caution to avoid longterm use, to be sure the tourniquet was needed, but to avoid it if possible. A number of improvised tourniquets were believed equally effective.

## World War II

Hamilton Bailey edited a very comprehensive book entitled, *Surgery of Modern Warfare*, published in 1941. This book devoted a whole chapter to tourniquets. He defined a tourniquet as a “. . . gross form of ligature

which is applied to a limb to prevent bleeding which cannot be stemmed by other available means.” He mentioned that seldom, if ever, venous bleeding requires a tourniquet, as it will almost always stop with pressure and elevation. For the purposes of his book, tourniquets are only used for arterial bleeding. He mentioned three primary uses for tourniquets: control of primary arterial hemorrhage; reactionary and secondary hemorrhage (having a tourniquet in place, loosely applied, in case a stump begins to bleed); and to render a surgical field bloodless. Bailey wrote briefly of improvised tourniquets, including neckties, handkerchiefs, and strong bandages. He included a comprehensive list of commercially produced tourniquets available in 1941 to the British soldier, including Samway’s tourniquet, Esmarch’s bandage, the pneumatic tourniquet, St John Ambulance tourniquet, Singer’s tourniquet, and the LPL tourniquet. Bailey finished the chapter by listing precautions and dangers of tourniquets. He emphasized the proper labeling of cases. He mentioned that inadequate pressure of a tourniquet can actually increase bleeding by failing to compress the artery and by impeding venous flow. He also cautions against excessive pressure, which can do unnecessary damage, especially in the arm, and he expresses concern about imperfect fixation, prolonged fixation, undue manipulation, and local skin damage. Bailey was not totally in favor of the use of tourniquets. Bailey’s belief in the value of the tourniquet was balanced by caution and respect. The tourniquet is “to be regarded with respect because of the damage it may cause, and with reverence because of the lives it undoubtedly saves. It is not to be used lightly in every case of a bleeding wound, but applied courageously when life is in danger.”<sup>8</sup>

Another pertinent book appeared also in 1941, *Medical Department Soldier’s Handbook*, as our troops were preparing for World War II. It discussed the common tourniquets of the day, mentioning again “the Spanish windlass,” which continued to be a very popular, improvised version. It stated that:

. . . any smooth, hard object, such as a stone, a cork, or a roller bandage is used as a compress: for the band, a handkerchief, a suspender, a waist belt, or a bandage may be used. To tighten the band a stick, bayonet, or scabbard is passed under the band and twisted until the bleeding ceases, and the ends tied to

the limb to prevent the band from becoming untwisted.

It warns that:

Applying a tourniquet may be a dangerous procedure and should not be used if bleeding can be stopped by other means. The dangers of a tourniquet are that if applied tightly enough to control arterial hemorrhage it will cause pain and swelling of the part below the constricting band. It should therefore be watched and released at about half-hour intervals. The tourniquet itself should be at least an inch wide, for if it is too narrow, it will cut off the entire blood supply to the injured part and require very frequent removal.

The reader is also warned never to cover up a tourniquet, because it might be neglected.<sup>9</sup>

A historical review of World War II medicine was published by the United States Army Medical Department in 1992. This book mentions tourniquets in passing: “Soldiers—whether medical or nonmedical—regularly misused tourniquets. They applied them unnecessarily; left them unloosened for too long; and occasionally evacuated patients with tourniquets concealed by blankets or clothing, and hence not discovered until the limb was doomed.” Trying to prevent such abuses, the Seventh Army surgeon directed that the “sole indication” for applying a tourniquet should be “active spurting hemorrhage from a major artery” and that medics in the field or at battalion aid stations should note the presence of a tourniquet on a patient’s EMT (emergency medical tag) in capital letters.<sup>10</sup>

The lesson from World War II was that misuse or inadequate observation of tourniquets could outweigh their benefit; they should be used for only obvious arterial bleeding.

### **Korean War**

Dr Carl W Hughes was a prominent military surgeon during the Korean Conflict. He recalls this about tourniquets: “I had a number of vascular injuries sent to me with tourniquets applied. I believe that they were mainly the pneumatic tourniquets. I do not recall ever seeing limb loss as a result of a tourniquet. They were important, even life-saving, in Korea. Successful use of the tourniquet depends on what it is made of, and how it is applied” (CW Hughes, personal communication, July 19, 2005).

Dr Hughes and Dr Warner F Bowers published *Surgical Philosophy in Mass Casualty Management* in 1960,

just a few years after Korea. Their comments are typical of many others, reflecting some mixed feelings about the tourniquet:

Even the use of a simple apparatus like the tourniquet has been a thorny problem requiring National Research Council advice on more than one occasion. Formerly, technicians were taught to apply the tourniquet to stop severe arterial bleeding and this is on the false assumption that a layman can distinguish between venous and artificial [sic] bleeding. Next, the tourniquet almost never was applied properly and everyone who has ever worked in an emergency room knows that the first act should be to take off the tourniquet so the wound will stop bleeding! Then, it was taught that the tourniquet should be released briefly every 20 minutes to allow some blood to get into the extremity. The patient, if the tourniquet really was needed, was allowed to exsanguinate slowly by increments each 20 minutes. This could be extremely serious in a 6- or 8-hour litter haul. Later, reasoning from the fact that orthopaedists leave a tourniquet on the extremity at operation for up to 3 hours, it was taught that release should be effected at about 2-hour intervals. This still does not cover the unneeded application, the improper application, and the increments of hemorrhage. Finally, it was realized that a good pressure dressing answers almost every need for a tourniquet and it now is taught that the pressure dressing is preferred. If a tourniquet is used, it should be with the idea that it is a physiologic amputation that is to be completed later.<sup>11</sup>

The lesson from Korea seems to be that tourniquets could be of benefit or of harm, depending on the circumstances.

### Vietnam

There are multiple anecdotal accounts of tourniquets in Vietnam. Dr John E Hutton recalls his personal memories of the use of tourniquets there:

For the most part, tourniquets were successfully improvised using rubber tubing, belts, rifle slings, and plain gauze wrapping. The medics were careful not to overconstrict the tourniquets, but would tighten them just to the point of hemorrhage control. Fasciotomies were sometimes used when tourniquets had been left in place in excess of 2 hours. Most of our medics were college graduates, were bright, and well-trained. We did not see the inappropriate use of tourni-



**Figure 4.** This photograph is from the collection of Dr John E Hutton, and illustrates a soldier who has suffered a mine injury during the Vietnam War; a rubber tourniquet has been applied to the left leg just above the knee and is being held tight by a surgical clamp.

quets and we definitely did see some lives saved because of them (Dr John E Hutton, personal recollections). (See Fig. 4.)

## CIVILIAN USE OF TOURNIQUETS

### American Red Cross

During the Vietnam era, civilian training in the use of tourniquets began to change to reflect the changes in emphasis seen in the preceding wars. It is interesting to contrast the advice given from the American Red Cross about tourniquets over the years. For instance, the 1925 manual has a fairly extensive section on tourniquets, including two pictures, one of the US Army tourniquet and one of an improvised tourniquet. The reader is encouraged to improvise when necessary: "The inner tube of a bicycle tire makes an excellent tourniquet. Its end is used for a pad. . . . Ready made tourniquets with straps, buckles, and pads may be bought. They are more convenient to use." A full page is devoted to necessary cautions that need to be heeded if a tourniquet is applied, including the mortification of limbs if the tourniquet is left on too long, the dangers of concealing a tourniquet, and the disadvantages of using a rope versus an elastic bandage.<sup>12</sup>

On the other hand, the 1992 *American Red Cross First Aid & Safety Handbook* never mentions the word *tourniquet*, and seems positively opposed to teaching the lay public about its use. In the section about stopping bleeding, the rescuer is told to first attempt to arrest hemorrhage by pressure, and if that does not work, by elevating the injured extremity. If that maneuver fails to stop the

bleeding, the next step is to apply a pressure dressing. If that does not work, the next step is to apply "pressure point bleeding control." If the bleeding stops after direct pressure but then restarts, one is told to reapply direct pressure. If all else fails, one is told to "get medical help."<sup>13</sup>

### Boy Scouts of America

Many young men growing up in America first heard the word tourniquet as part of a talk on first-aid at a Boy Scouts meeting. One suggested the use of tourniquets used to be for treatment of snake bite, although more recent advice has changed: "Do not suck the venom out. Do not constrict blood flow with a tourniquet. In Boy Scouts, National Outdoor Leadership School, and Outward Bound, use of tourniquets is forbidden. Their use might have been taught in the 1950s and 1960s, but not now. They are used only in situations where amputation of the limb is unavoidable."<sup>14</sup> The Boy Scouts First Aid Merit Badge requirements mention the tourniquet. A Scout who qualifies for this merit badge must be able to: "Show the steps that need to be taken for someone suffering from a severe laceration on the leg and on the wrist. Tell the dangers in the use of a tourniquet and the conditions under which its use is justified."<sup>15</sup> More seems to be mentioned about the dangers of tourniquets in modern scouting than about their usefulness.

### Advanced trauma life support

The most recent *Advanced Trauma Life Support* course (7<sup>th</sup> edition) does not teach how to apply tourniquets, but exhorts students to avoid ". . . blind clamping and applying a tourniquet." The chapter devoted to the treatment of shock emphasizes hemorrhage control using direct pressure, splinting, reducing pelvic volume, or operating. The student is told that tourniquets should not be used, except in exceptional circumstances, such as traumatic amputation. Of course, *Advanced Trauma Life Support* advice is intended primarily for the hospital setting, where more appropriate surgical control should be quickly available. The "Austere Environment Module" describes situations when the resources of the hospital might not be available, and notes that a tourniquet could be appropriate and lifesaving.<sup>16,17</sup>

### The public

The *US Army Survival Manual* was privately published and sold to the general public; it contains some good tips

on field medicine. There is a small section of the book that deals with tourniquets. Recommendation is that only after direct pressure has been tried and fails should one resort to use of a tourniquet. Tourniquets are not recommended for general use because when left in place, tissue damage results, with loss of limb. If partially occluding, tourniquets can actually increase hemorrhage. Tourniquets can permanently damage nerves and other tissues where applied, if done improperly. The methods of application of a tourniquet are explained. The injured person is instructed to leave the tourniquet in place, once applied.<sup>18</sup>

## CURRENT MILITARY PRACTICE

### Operation Iraqi Freedom

A recent front-page article in the *Baltimore Sun* was highly critical of the US Army, suggesting that our soldiers are sent into battle without adequate methods of hemorrhage control. This article claimed that lives are being lost on the battlefield simply because a rudimentary "\$20 nylon-and-plastic tourniquet" was not universally fielded with the troops. The *Sun* estimated that by spending \$2 million, all deployed troops could be equipped with these "modern tourniquets" and more lives would be saved. The article stated that the loss of blood from an extremity wound was "the most common cause of preventable death in combat," and offered great detail about the usefulness of tourniquets on the battlefield. It noted that almost all of the 50,000 Special Forces and Rangers go to war with this new tourniquet. It suggested that units that deploy with these tourniquets never seem to suffer fatalities from extremity hemorrhage. The article also claimed that the bureaucracy of the military was withholding a new and proved therapy by delaying the rapid manufacture and distribution of a particular tourniquet. Several accounts of wounded soldiers are included in this article, which describes some difficulties that can occur with use of improvised tourniquets. Several trauma-care experts are interviewed in this article, all expressed dismay that tourniquets are not standard military issue, all hoping that this deficiency is quickly corrected. The article is noteworthy in that it mentioned few of the disadvantages of tourniquets.<sup>19</sup>

Since the appearance of the *Baltimore Sun* article, other articles mentioning this same concern about lack of tourniquets have also been printed. Congress investigated these charges, and some attempts have been made

by the military to answer the allegations. There have been many tourniquets used in Iraq. One surgeon's recollections are as follows: "We saw dozens of tourniquets used. For the most part, they were appropriately placed—however some were not, with the obvious outcomes. We did not see vascular ischemia from prolonged usage (due to relatively short aerovac and transport times). Overall, tourniquets were extremely valuable—lifesaving and priceless! We did see a few cases where QuikClot was used and a tourniquet would have been more appropriate. Thousands of tourniquets were distributed throughout the 3<sup>rd</sup> Infantry Division while I was there" (Dr Kenneth S Azarow, personal communication). A training issue is the correct use of QuikClot, because of the potential for tissue damage from heat production. This product should only be used after traditional methods have been tried and have been found to be unsuccessful.<sup>20</sup>

### CURRENT COMBAT TRAUMA USAGE

The pendulum has begun to swing back from avoidance to encouragement. What prompted these changes? There has been a new emphasis on the role of the medic in saving lives on the battlefield. Most casualties who die on the battlefield die fairly quickly and before they get to a physician. About half of these die from hemorrhage, and a large number of those from extremity hemorrhage. If there is an opportunity to save their lives, it will be in the hands of the medic, the soldier, and their fellow soldiers in the field. Although direct pressure is the first line of defense against hemorrhage, it is not appropriate to expect the medic under fire to hold pressure. If there are multiple casualties, there are not enough people to hold pressure. Finally, during movement of the patient to surgical care, on air, land, or sea transport, pressure might not be adequately maintained. In such situations, the tourniquet offers a life-saving solution and has received primary emphasis in training. To overcome perceived prohibitions against tourniquets, the risk of limb loss has been downplayed. When surgical care can be quickly reached, allowing early release of the tourniquet, then risk of limb loss is very much decreased, and the benefit of hemorrhage control clear. It should be noted that most of the casualties in the current conflict in Iraq arrive at surgical care within 1 hour. With increasing time to surgical care, the risk of limb loss increases. The tourniquet can still be necessary to save a life, and can represent an appropriate choice—but it must be recog-

nized that a choice has been made. Denying that there is a possible downside to tourniquet use cheapens the choice, and can lead to increased misuse.

### MILITARY TRAUMA INSTRUCTION

*Emergency War Surgery* is a US government publication given to all military surgeons before going to war. The advice in this book has been carefully vetted by acknowledged authorities in the field of trauma and critical care. There is a brief mention of tourniquets in the 1988 edition:

A tourniquet may be required to control hemorrhage, especially for the casualty with a traumatic amputation. A properly applied tourniquet, while endangering the limb, can save the life. An improperly applied tourniquet threatens both life and limb. A common mistake is inadequate compression that fails to occlude the artery but does occlude venous return. This results in an increased rate of blood loss. The tourniquet should be placed as distally as possible, just proximal to the wound. Once in place and adequately controlling hemorrhage, it should not be released until the casualty reaches a definitive care facility. The time and site of tourniquet application should be recorded clearly on the field medical card, and evacuation should be accelerated.<sup>21</sup>

This guide was revised and reissued in 2004, with a whole new, small section on tourniquets. The information given is essentially unchanged. The newer manual encourages use of tourniquets early, rather than allowing ongoing blood loss. The manual states that tourniquets have some definite advantages. Blood loss is quickly stopped, for instance. Also, tourniquets do not require constant attention, allowing first responders to help others. Ideally, tourniquets are placed as close to the wound as possible, but sometimes it is necessary to apply them away from the wound, to get adequate arterial compression and hemorrhage control. The new guidebook highlights several important concepts: The tourniquet might be the first choice in combat. Application of a tourniquet for longer than 2 hours can increase limb loss. A risk-to-benefit decision must be made when deciding on a tourniquet. Although a distinct possibility, careful use of a tourniquet does not invariably lead to limb loss. This depends on a number of factors, including time to definitive care. The rescuer should never allow a life to be lost to save a limb.<sup>22</sup>



**Figure 5.** This photograph is of the new field tourniquet, currently in use in Iraq, which features a built-in windlass.

In the past few months, a new field tourniquet has been quickly developed, tested, and sent to the troops in Iraq and Afghanistan. The key improvement in the new field tourniquet is that it can be self-applied by the wounded soldier using only one hand. Although this tourniquet has been shown by Doppler evaluation to occlude distal pulses, it is less clear that it is more effective than other tourniquets. Some anecdotal reports suggest that it requires two of these tourniquets to adequately occlude the thigh on a large soldier. In addition, some have suggested that the loop and hook fastener fabric does not hold if the tourniquet becomes muddy (Fig. 5). We do not have data about the exact numbers of tourniquets applied, lives saved, and limbs lost in the current conflict. We do have anecdotal information to indicate that tourniquets are making a difference in Iraq and Afghanistan.

## OPERATING ROOM

An argument against the prohibition of tourniquets can surely be made by observing what happens, on a daily basis, in the modern operating room. All across America, literally thousands of tourniquets are applied during operation to prevent excessive blood loss and to create a bloodless operating field, while operating on the extremities. These tourniquets are used with very few complications or mishaps. By teaching the same principles as those followed in our operating rooms, surely many of the concerns of tourniquets are answered. Some of these principles are as follows:

1. "Correct pressure is the minimum amount required to produce a bloodless field." Often this is 30 to 70 mmHg greater than the systolic pressure. For an average adult, tourniquet pressure is usually around 250 to 300 mmHg.
2. "Inflation time should also be kept to a minimum." The tourniquet should be deflated after an hour on the arm, and  $1\frac{1}{25}$  hours on the leg, and then reapplied.
3. Wrinkle-free padding is applied to the extremity under the cuff.
4. The cuff is placed at the point of maximum circumference on the extremity.
5. Vulnerable neurovascular structures should be avoided. Place the cuff on the upper third of the thigh or the upper arm.
6. Wide cuffs should be used to spread the pressure exerted and decrease tissue damage under the tourniquet.
7. Careful monitoring of tourniquet times, and reminding the operating team about the times, is important.<sup>23</sup>

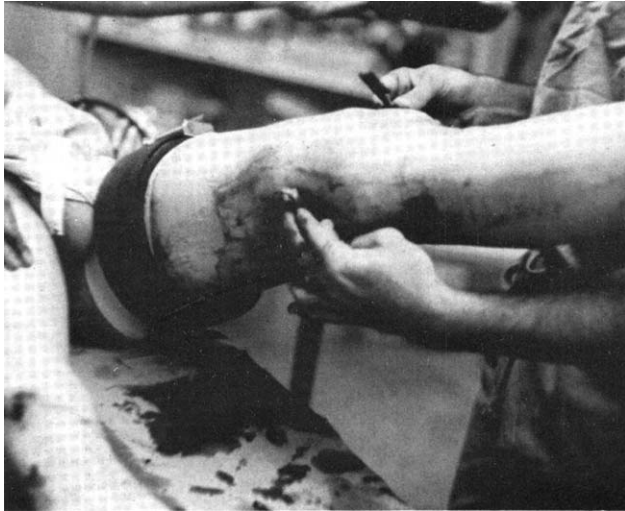
## SURGICAL LITERATURE

*Vascular Trauma*, by Rich and Spencer,<sup>24</sup> recommends packing of wounds containing arterial injuries, followed by judicious application of a pressure dressing, which usually controls hemorrhage. The authors state the following about tourniquets:

Rarely, a tourniquet is necessary. This is fortunate, because there are several dangers with the use of a tourniquet. When a tourniquet is used, the limbs should be carefully padded beneath the tourniquet, and preferably a pneumatic type of tourniquet should be used. A narrow, constricting tourniquet can cause irreversible injury to underlying nerves, even though the arterial repair is successfully performed. If a tourniquet is not applied tightly enough, venous return is interrupted but arterial inflow continues, resulting in increased hemorrhage from the wound. . . . An additional disadvantage is the fact that a tourniquet deprives the entire extremity of arterial flow, both through collaterals and through the injured artery. In Jahnke's report of the Korean experience (1953), all patients who later underwent amputation after attempts at arterial repair had had a tourniquet applied to the extremity for a long period of time. In Vietnam, tourniquets were seldom found necessary. . . .<sup>24</sup>

Dr Rich recalls how improvised tourniquets were sometimes used in Vietnam, including use of the military web belt on the thigh of a bleeding left leg (Fig. 6). As well, Dr Rich had one memorable case of a young soldier who was bleeding briskly from a right upper arm injury, which had been treated by application of a tourniquet at the shoulder.





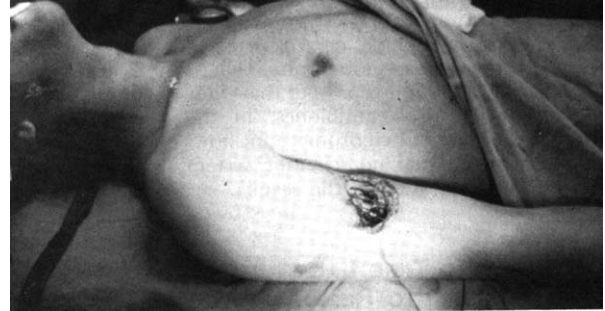
**Figure 6.** This photograph shows a web belt, an improvised tourniquet, applied to the left thigh above a vascular injury as the patient is being prepared for operation. (From the collection of Dr Norman M Rich, 2<sup>nd</sup> Surgical Hospital [MASH], 1966, An Khe, Republic of South Vietnam.)

When the tourniquet was released, the bleeding ceased. It turned out that this was a simple cephalic vein injury, and the tourniquet was not applied properly, and was not occluding the arterial inflow completely (NM Rich, personal recollections) (Fig. 7).

### CURRENT RECOMMENDATIONS FOR USE OF TOURNIQUETS

As recommended by *ATLS*,<sup>16,17</sup> try all other means to stop hemorrhage, including direct pressure, pressure dressings, and even, if possible, judiciously applying a hemostat, before considering a tourniquet. If the field situation precludes other methods of stopping hemorrhage, consider the following:

1. Use a wide tourniquet if possible.
2. Use padding under the tourniquet, to avoid skin and soft tissue damage.
3. When applying a tourniquet, avoid the impulse to “only put it up partway”; it should be fully applied, with high enough pressure to completely occlude arteries and arterial bleeding.
4. Record in an obvious place (ie, forehead) on the patient when the tourniquet is applied.
5. Ensure that others, along the chain of evacuation of a war casualty or a civilian accident patient, know that a tourniquet has been applied.
6. Avoid covering up a tourniquet in the unconscious patient.
7. Remove the tourniquet at the very first opportunity.



**Figure 7.** This photograph illustrates a right upper arm injury, which involved the cephalic vein, and which had been treated with a tourniquet. The patient was bleeding massively from this wound, and the bleeding ceased immediately when the tourniquet was removed. The tourniquet was not occluding the artery sufficiently, and was contributing to the hemorrhage. (From the collection of Dr Norman M Rich, 2<sup>nd</sup> Surgical Hospital [MASH], 1966, An Khe, Republic of South Vietnam.)

8. If a patient has stopped bleeding from an extremity wound, and is about to be transported over some distance, a tourniquet very loosely applied might be useful in case massive hemorrhage occurs en route. Quick deployment of such a tourniquet might be life-saving.

### SUMMARY

Many surgeons, over the centuries, have noted the risks versus the benefits of tourniquets. As new providers see hemorrhage from extremity wounds, they should be trained in the use of tourniquets, to have a thorough understanding of their risks and how to use them to best benefit. The following quote, in particular, is a good choice to end this review, as it comes from an early, serious treatise on blood vessel injuries, written by a preeminent surgeon, Sir George Henry Makins, in 1919, and because it encapsulates all the issues of tourniquets:

The last resource for temporary control of bleeding, the application of a tourniquet, is a vexed question not easy of solution. Every surgeon would gladly eliminate this dangerous and clumsy procedure from his practice. Yet circumstances do occur when the use of the tourniquet is unavoidable, such as the absence of skilled assistance, want of time, the position in which the patient may find himself situated, or the nature of the surroundings. It can only be said, therefore, if the tourniquet be the sole available means of temporarily arresting the haemorrhage, that every precaution must be taken to make sure that the band is released at the earliest possible moment; further, that no patient be subjected to trans-

port without being specially marked, so that the presence of the tourniquet be not overlooked. Even when the latter precaution is observed, the evil effects of too tight or too prolonged application of the tourniquet are unhappily far from unfamiliar. Naturally the most frequent instances of the evil effect of the tourniquet are seen in patients who have either constricted their own limbs, or in whom the tourniquet has been applied by a fellow soldier.<sup>25</sup>

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