# WO-15 Making and salvaging the instruments: knives, needles, forceps, sutures, dressings

HEALING after the FALL, research library, WO-15

Researched 10 October 2026 by Claude Opus agent for THRIVING after the FALL, Book Four. Library document, unverified.

## How to read this report

Three questions run through it. What does a village actually need. What can be made by a smith, a seamstress and a careful householder. What must be taken off the shelves now, because nobody will make it again in a lifetime. The answers differ for a scalpel, a needle and a roll of bandage, and the differences are the whole practical argument.

Sterilisation itself is in the library and not repeated here (THRIVING library, WO-12). Whether to close a wound at all, and the clinical comparison of suture materials in the body, is in WO-03 and only extended here (THRIVING library, WO-03). Of the related reports the brief names, only WO-12 and WO-03 existed when this was written, so the stethoscope and thermometer are treated only as objects to make and salvage.

## 1. Findings by section

### 1.1 What a minimum set actually is

Four published lists answer this, and they are startlingly close. That convergence is the most useful finding here, because a village need not guess.

**The IFRC and ICRC basic surgery set** (KMSISBAS01) is 24 line items, 51 instruments, 4.72 kg, stated as sufficient for hernia repairs, appendicectomies and tracheotomies (IFRC, n.d.). It holds scalpel handles No 3 and No 4, three scissors (Mayo 17 cm, Metzenbaum 18 cm, Nelson-Metzenbaum 23 cm), two dressing and two toothed tissue forceps at 20 cm, a Mayo-Hegar needle holder 15 cm, twenty haemostats (six curved mosquito 12.5 cm, six straight and six curved Crile 14 cm, two Ochsner 16 cm), six Backhaus towel clamps, two Foerster sponge forceps, three Volkmann rakes, two Langenbeck, a Weitlaner and an Adson retractor, two Allis forceps, a kidney dish, a bowl and a lidded sterilising basket.

**The MSF basic surgery set** is 25 instruments and overlaps almost exactly, adding a Collin oval-jawed forceps, a probe, Farabeuf retractors and a second needle holder (MSF Unicat, n.d.).

**The WHO Generic Essential Emergency Equipment List** is shorter. Its capital items are bag-valve-masks, oxygen, a stethoscope, suction, blood pressure equipment, a thermometer, a scalpel with blades, a retractor, scissors, airways, an artery forceps, gloves, a needle holder, a steriliser and a speculum. Its renewables are nasogastric tubes, a lamp, an infusion set, cannulas, syringes and needles, a sharps container, a tourniquet, sutures, splints, Foley catheters, masks, gowns and soap (WHO 2003).

**King's Primary Surgery**, chapter 4, is the richest, written for someone who may have to create a theatre from

nothing (King et al. 2011). Its ordering rule is six-fold. The item must work reliably, work in your hands, be affordable to run, have spares, be teachable, and be repairable locally.

The four agree on a core of nine things: a cutting edge, scissors, a toothed and a plain dissecting forceps, several artery forceps, a needle holder, needles, thread and retractors. Six artery forceps is the number that recurs. For a dispensary of 300 the honest minimum is that core plus a sponge forceps, four towel clips, a kidney dish and a sterilising tin, which is roughly the MSF set. For a district infirmary of 3,000 it is two such sets, so one sterilises while the other works, plus abdominal retractors, longer scissors, a second needle holder, and the obstetric, dental and chest instruments.

One conflict is worth knowing. The IFRC catalogue puts blades 10, 11 and 15 on a No 3 handle and blade 20 on a No 4. King puts blades 10 to 19 on a No 5 handle and 20 to 36 on a No 4. The No 3 and No 4 pairing is what commercial catalogues use. Take both patterns.

### 1.2 The history, and what it tells a village

Al-Zahrawi, working near Cordoba, finished the surgical volume of *Al-Tasrif* near the end of the tenth century. It describes and illustrates more than two hundred instruments, most of them his own designs, including scalpels, curettes, retractors, hooks, sounds, specula, a tooth extractor, a catheter and dental scalers (Hektoen International, n.d., Rare Books Digest 2014). Sami Hamarneh's Smithsonian study warns that the drawings in later manuscripts are greatly modified, so the circulating images are not reliable patterns. The shapes a village needs were settled a thousand years ago. The barber-surgeon's chest from the *Mary Rose*, sunk 1545 and raised 1982, held over sixty medical objects, including razors, three syringes, a bloodletting bowl and jars of ointment (Mary Rose Trust, n.d.). A ship's surgeon's whole kit was a chest one man could carry, which calibrates the modern lists.

The American Civil War gives the best record of a standardised minimum. After Manassas the Union Medical Department bought sets from Tiemann, Hernstein and Kolbe. The official field operating case held amputating knives, catlins, scalpels, bistouries, three saws, a trephine, bone, artery, dressing and dissection forceps, twelve surgeon's needles, a screw tourniquet, a tenaculum, scissors, retractors, a trocar and cannula, a raspatory, an elevator, a bullet probe, six bougies, nine catheters, twelve yards of iron suture wire, and ligature silk and wax (Medical Antiques, n.d.). Twelve reusable needles and twelve yards of wire served a surgeon for a campaign. That ratio matters after the Fall.

Handles tell the story of sterilisation. Civil War knives had cross-hatched ebony handles, chosen for grip, and a museum note observes that ebony was difficult to sterilise. Roman scalpels were steel blades in bronze handles, and in many graves the bronze survives while the iron blade has gone. When boiling and then steam came in after Koch's work of 1878, wood, ivory, shell and horn had to go, and the all-metal instrument is the result (Kirkup 1982, metadata only, Kirkup 1993, search summary). Harry Brearley's 12.8 per cent chromium, 0.24 per cent carbon steel of 13 August 1913 completed the change (Cedinox, n.d.). After the Fall this runs backwards, and King states the old discipline flatly. Wipe ordinary steel with an oily rag after each operation, and never store it sterilised inside packs or drums, because the interior is damp and it will rust rapidly.

### 1.3 Salvage: what to take first

The order follows from what cannot be made.

1. **Needle holders with tungsten carbide jaws.** No village forge makes a box joint, a ratchet and a carbide insert. King notes they cost twice as much and last more than twice as long. The most valuable small objects in a clinic.
2. **Artery forceps**, six to twelve, mosquito and Crile. Bleeding kills faster than sepsis.
3. **Scissors**, Mayo and Metzenbaum. A smith can make a crude pair, not one that cuts to the tip.
4. **Scalpel handles and whole boxes of blades**, and solid forged scalpels, because King records that their advantage is that you can resharpen them.

5. **Eyed surgical needles.** King's note is decisive. A Keith straight triangular 64 mm needle is easy to sharpen and one may last a year.
6. **Sealed commercial sutures.** King states that although these carry an expiry date, their reliability lasts at least 12 to 24 months past it. That is the only quantified guidance found anywhere, and it sits awkwardly beside the library's note that suture perishes in storage (THRIVING library, WO-03). Both are probably right about different materials. Sealed monofilament should outlast the date. Catgut in fluid will not.
7. **Catheters, nasogastric and stomach tubes, chest drains.** Foley 12 to 18 Charriere, Ryle's Ch14 to Ch18. Nothing below a chemical works makes these.
8. **Glass or metal syringes, and hypodermic needles of every gauge**, which are dual-use, as section 1.6 shows.
9. **Dental extraction forceps and elevators.** A nineteenth-century dentist recorded that some practitioners kept not more than five or six forceps and two or three elevators for all cases, while others wanted forty or fifty (dental literature 1876, search summary). The MSF field dental set is 20 instruments. Five or six forceps and two elevators is the village number.
10. **Retractors**, last, because King names four malleable copper strips bendable to any shape, and copper sheet is within reach.

Then the general-purpose steel: a hard Arkansas oilstone 150 by 70 by 30 mm, which King names for scalpels and scissors, a carborundum stone for very blunt instruments, pliers, a carpenter's drill, and bicycle spokes, which King offers in place of Kirschner wire.

The baseline for what will be found is poor even now. A scoping review of 40 studies covering 641 hospitals in low and middle income countries found steam autoclaves in 37 of 39 studies and boiling still in use in 9 (23 per cent), with large gaps between practice and policy (Forrester et al. 2018). Across 11 African countries 62 per cent of sterilisers were reported as functioning well (ICAN survey, search summary), Kenyan level 4 hospitals had sterilisation equipment in 42.6 to 68.3 per cent of facilities (Annals of African Surgery 2025, abstract), Nigerian primary care had autoclaves present in 21.5 per cent and functional in 14.9 per cent (Nigeria readiness study 2017), and in Arua, Uganda, half of 32 facilities had a functional autoclave (Uganda study 2015). Expect half the sterilisers found to be dead, and the instruments to outlast them.

### 1.4 The smith: what can and cannot be made

This is where craft sources overstate the case.

**What the steel must do.** ASTM F899 gives 420C, hardened from 1038 °C and tempered at 149 °C, a hardness of 58 HRC, and lists it for scissors, bone rongeurs, scalpels, knives, curettes, chisels and gouges (ASTM F899, search summary). Martensitic instrument steels run roughly 0.10 to 0.60 per cent carbon with 12 to 14 per cent chromium (Cedinox, n.d.). Swann-Morton, which makes both carbon and stainless blades to BS 2982 and BS EN ISO 7153-1, says plainly that carbon steel gives the best combination of initial sharpness and durability, and that stainless is chosen for corrosion resistance.

So the target is a blade at 58 to 60 HRC holding a very fine edge, which is exactly a bladesmith's target. FEASTING after the FALL's forge documents give the numbers, all marked unverified by that book's own author. Harden plain 0.8 per cent carbon steel from 800 to 815 °C and leaf spring from 830 °C, quench in oil, and temper within the hour at 200 °C for two hours, twice, giving light straw and 60 Rockwell. Never temper between 230 and 315 °C, the purple and blue trough where the steel goes brittle by a second mechanism. Normalise three times at 900, 815 and 730 °C in still air first, because hammering leaves a coarse grain and a coarse grain makes a brittle blade. Leave the edge 1 mm thick before the quench or it warps. Of the salvage steels, plain 1084 bar forgives every error but overheating, the leaf spring at about 0.6 per cent carbon wants a slower oil and cracks in a fast one, and the file at a full one per cent carbon is the fussiest. Tool steels with tungsten and chromium want a kiln holding temperature for half an hour, and a box of dirt cannot do it (FEASTING after the FALL, "The Knife", 2026). Bladesmithing practice adds that

used springs may carry micro-cracks and may not be the alloy expected, since leaf springs are made from several steels (machinemfg, n.d., BladeForums, n.d.).

**Instrument by instrument,** in descending order of confidence. A **solid forged scalpel** is a very small knife with a 30 mm blade at about 58 HRC, reground every few operations. This is the clearest yes in the report. **Retractors**, including Langenbeck and Czerny patterns and malleable copper strips, are bent and filed sheet, and are easy. **Probes, directors, elevators, raspatories and bone levers** have no joints and are straightforward. **Straight needles** are drawn wire, flattened, the eye drifted, the point ground, hardened and tempered. **Curved needles** are harder, because the curve is formed before hardening and the eye must not crack. The commercial route drills the eye with carbide bits (US Patent 5776268, 1998), and a village must drift or file it instead, giving a thicker eye and a bigger hole in the tissue. **Scissors** are possible but difficult, because two blades must meet along their whole length with a slight set and stay in register at the joint, so a village pair will cut near the joint and not at the tip, which is where King says to cut. **Artery forceps with a working ratchet, and needle holders**, are where craft optimism fails. A box joint is two halves machined to interlock, and a ratchet is matched racks that must engage with the jaws just closed. Both are fitting work to a fraction of a millimetre in hardened steel. A skilled smith with files, time and a pattern can make one. A village cannot make twelve. **Tungsten carbide anything** is no.

This matters clinically. The instruments a village can make are the ones that cut and hold the field open. The ones it cannot make are the ones that stop bleeding and drive a needle. A village with a forge and no salvaged haemostats will have a surgeon who can open and cannot close.

### 1.5 Care and sharpening

Instruments are destroyed by chemistry more often than by use. The thin chromium oxide film on stainless steel is what resists corrosion, and all instrument care is protecting it (Purdue CIS, n.d., Belimed, n.d.). Chlorides break it and cause pitting, the two usual sources being blood left to dry and rinse water high in chloride. A French laboratory study found that softened rinse water promoted rust, and that corrosion fell when the water was changed and dynamic drying introduced (em-consulte 2020, abstract). Lime deposits shelter corrosion, and instruments reprocessed closed can crack by stress corrosion, so they are cleaned and sterilised open.

The library's cleaning rules stand. Clean first, open hinges, keep the water below 60 °C because protein coagulates above it, and do not pre-soak in chlorine (THRIVING library, WO-12). Three post-Fall rules go with them. Rinse finally in rainwater or boiled settled water. Dry fully and at once. Oil carbon steel after every use and store it dry and unwrapped (King et al. 2011).

**Sharpening.** King names the tools: a hard Arkansas oilstone 150 by 70 by 30 mm for scalpels and scissors, and a carborundum stone first for a very blunt instrument. Scissors are sharpened only on the outer bevel of each blade, never on the inner faces, because those are the shearing surfaces and grinding them opens a gap. A scalpel is sharpened as a knife, the burr raised and chased from side to side until it falls, then stropped on leather.

**Does a worse edge matter?** Indirect evidence says yes. A guinea pig study comparing a standard blade with a nano-polished blade found less bleeding, better wound adherence, lower macrophage density and less scar with the smoother edge (MDPI 2025, abstract), and a diabetic rat study found rough edges caused shear stress, tearing and increased inflammation (search summary). Neither tested a resharpened blade, and much publicised human data comes from the company making the polished blade, so the claim must be held loosely. A dermatology unit reports resharpening punch biopsy forceps over six months in a resource-poor setting (Cosmoderma, n.d.). No study compares resharpened with new scalpel blades for infection or healing. That is a real gap.

### 1.6 Needles

A needle makes a hole, drags thread through it, and survives steel jaws. Eyed needles make a hole wider than the thread, because the thread doubles at the eye. Swaged needles have the thread fixed into a channel in a blunt end, so the hole

matches the thread, and they are why modern sutures cost what they do.

Point types are taper, cutting (edge inside the curve), reverse cutting (edge outside), taper-cut or trocar, blunt and spatula. Curves run straight, quarter, three-eighths, half and five-eighths circle (US Patent 5776268, 1998, mr-cophth.com, n.d.).

King's rules are the practical core. Always use a cutting needle for skin, either straight, half-curved or large curved held in the hand, or a smaller curved one in a holder, and a cutting needle for tough fascia. Use round-bodied or taper-point needles for most other tissue, partly because of needle-stick risk. The narrower and deeper the space, the smaller and more curved the needle. Hold a curved needle at the middle of its curvature at the very tip of the holder, with no jaw protruding, and follow the curve as it passes. Re-sharpen cutting needles on a stone (King et al. 2011).

The village stock, reduced from King's list, is a Keith straight triangular 64 mm for skin, three-eighths circle curved triangular in sizes 4, 12 and 18, half circle curved triangular in sizes 2, 8, 14 and 20 for scalp, and round-bodied three-eighths circle in sizes 4, 10 and 18 for peritoneum and soft tissue. Twelve needles will serve a year if sharpened and not lost.

**The improvised swaged needle** deserves to be the most-copied paragraph here. Take a hollow hypodermic needle of the right size, thread the monofilament through it, snap off the plastic Luer hub, withdraw the thread into the metal, crimp the metal tight onto the thread, and bend it to shape, then use it in a needle holder (King et al. 2011, after Remis 1983). King's gauge table pairs USP 3-0 with 23, 24 or 25 gauge, 2-0 with 22, 0 with 20 or 22, and 1 with 20. This turns the most salvageable item in a clinic, the box of hypodermic needles, into atraumatic sutures.

### 1.7 Sutures and ligatures

WO-03 covers which material goes in which wound. This covers making and sterilising.

**Catgut** is made from the submucosa of sheep intestine or the serosa of beef intestine, cleaned of fat, soaked, the outer membrane scraped off, soaked again in alkali, stretched, twisted into string, dried and polished to diameter. King's clinical figures: plain catgut usually holds strength about 10 days, chromic about 20 but unpredictably, and sepsis may dissolve either in 2 to 3 days. While it absorbs it is a good culture medium and may promote sepsis, so use no more than necessary and avoid thick sizes.

Sterilisation is where it failed, exactly as the brief warns. Claudius published the iodine-water method in 1902, soaking raw gut eight days in one part iodine, one part potassium iodide and a hundred parts water, and users complained the gut became brittle and knotted less firmly (period reviews, search summaries). Boiling in alcohol for 45 minutes on three successive days was a competing protocol, and a 1937 note in *Nature* observed that heat needs great care while aqueous iodine was efficient and widely used. The Edinburgh outbreak settled it. In the 1920s at the Royal Infirmary of Edinburgh catgut had been used in all eleven cases of suspected or confirmed post-operative tetanus, and T. J. Mackie found the supplier's product contaminated because it had been prepared by methods devised thirty years earlier. He proposed batching, numbering and bacteriological testing, which became law in the Therapeutic Substances (Catgut) Regulations of 1931 (King's College London archive, n.d.). Gut string can be made, but it cannot be made safe to bury in tissue without a sterility test, and for skin stitches that come out anyway it offers nothing.

**Silk** is within reach wherever mulberry and *Bombyx mori* will live. Sericin is 25 to 30 per cent of the cocoon by weight and is removed by boiling in alkali, which costs strength: one degumming study found weight losses of 12.2 to 29.4 per cent and a negative correlation between weight loss and tensile strength. Raw silk tenacity is reported at 4.5 to 4.8 grams per denier and degummed at 3.3, and *B. mori* silk at about 0.5 GPa with 15 per cent elongation to break (Shao and Vollrath 2002, FAO, n.d.). In an in vitro study of 192 samples across six materials, silk came lowest at a mean 32.8 N against 38.7 N for polyglactin 910 and 37.1 N for polydioxanone (oral surgery study 2024). Silk is strong

enough. It is braided and holds bacteria (THRIVING library, WO-03), and steam sterilises it without the damage boiling causes.

**Linen and cotton.** King is encouraging. Silk, linen or cotton knot well and can be cut 2 mm from the knot, where monofilament needs longer ends, and linen or cotton thread can be used almost anywhere, especially as ties, bought on a reel and resterilised. He gives a worked case. Dr James Mukolage, recently qualified, found a woman in a village with bowel protruding from an abdominal wound, found local anaesthetic and linen thread in the shops, boiled a few instruments from the health centre, washed the wound, repaired a minor bowel cut and closed with linen thread. She survived. That is the best documented instance found of a village-grade suture working in a cavity.

**Fishing line.** King's table matches USP sizes to line breaking strengths and is reproduced in Protocol 6. He states that ordinary nylon fishing line is the same material as surgical suture and recommends 12 to 20 lb breaking strength for abdominal closure. WO-03 is more cautious, noting that fishing line was not made for implantation, that a veterinary study found ethylene-oxide sterilisation weakened three of four brands, and that in one knot study with large nylon more than 70 per cent of knots slipped. The material is right, the additives are unknown, and the knots need extra throws. Never grip monofilament with artery forceps or a needle holder, because it is seriously weakened at that point.

**Horsehair and steel wire.** Horsehair is a monofilament, used by Confederate surgeons when supply was cut, with no outcome data (THRIVING library, WO-03). Stainless steel wire knots superbly, is difficult to work with and is always used single. Salvaged soft stainless wire is a real option for tension sutures and for wiring bone.

**Sizes and knots.** The USP scale runs 6/0 to 4, with diameter roughly doubling each step, and King's rule is the thinnest suture as strong as the tissue, putting most operations between 3/0 and 1. Tie reef knots, never granny knots. A surgeon's knot is a reef knot with a third half hitch in the same direction as the first. For monofilament use two or more turns on each of the first two hitches and one on the third, and for multifilament a single turn on each of three hitches is enough. Set knots only tight enough to bring the edges together, because the skin will swell the next day.

### 1.8 Dressings

**Linen, lint and charpie.** Before manufactured dressings, hospitals accepted bundles of old rags as gifts, and lint was made by hand, the transverse threads of soft old linen drawn out, or the surface scraped with a knife to raise a cotton-like nap (Ragged Soldier, n.d.). Into the 1950s hospital nurses still made up dressings overnight and filled drums that went down to the theatre autoclaves (King's College London archive, n.d.). That history is the instruction. Boiled, dried and ironed linen, folded into a tin and steam-sterilised, is a complete dressing system, and it is what the richest hospitals used within living memory. The library gives the figures: 121 °C for 30 minutes for textile packs, double cotton wrapping, dry storage, a four-week limit (THRIVING library, WO-12). Ironing matters for a reason other than sterility, because a smooth lint-free surface sheds less fibre into the wound.

**Cotton wool.** Raw cotton is not absorbent, because the natural oils repel water, and ordinary carded cotton wool floats. The nineteenth-century answer was degreasing and bleaching. W. G. and J. Strutt of Belper produced a treated wool in 1879 which sank rapidly where ordinary wool floated, and in 1880 Sampson Gamgee of Queen's Hospital, Birmingham, demonstrated the same contrast and announced his sandwich of absorbent wool faced with bleached gauze in *The Lancet* (Cambridge *Medical History* note, n.d.). So cotton wool is a hearth product only where the fibre can be scoured, and the traditional route is boiling raw ginned cotton in weak wood-ash lye and rinsing thoroughly, though no source read gives household quantities [VERIFY]. The simpler answer is that linen needs no degreasing, which is one reason flax was the wound fibre of the ancient world.

**Sphagnum.** The brief warns that enthusiasm outruns the data, and it does. Colonel C. W. Cathcart of the Edinburgh Royal Infirmary compared sphagnum against cheap absorbents such as pine sawdust and peat litter and

published in the *British Medical Journal* in July 1915 (*Nature* 1941 review, search summary). The War Office approved surgical use, reportedly in February 1916, and ordered through the Dublin and Edinburgh War Dressings Supply Centres (Somerville College 2024). By the end of the war about one million dressings a month were being produced [VERIFY].

The absorbency figures do not agree. A *British Journal of Dermatology* abstract reviewing Cathcart and Balfour says 20 times its weight in fluid, a Birmingham historian says about three times faster than cotton, a Bradford account says up to ten times its own weight, and a general war history says more than twice as much as cotton wool. Horticultural sources usually give 20 times its own *volume*, a different quantity, and one museum note gives 30 times dry weight for *S. palustre*. The published spread is 2 to 30 in inconsistent units. The honest statement is that sphagnum holds several times its own weight, more than cotton wool, and that no popular figure should be quoted precisely.

The antibacterial claim is weaker. Sphagnan, a pectin-like polysaccharide released from the holocellulose, has been assessed for microbiocidal properties against pure bacterial cultures (Ballance et al. 2006, abstract), the proposed mechanism being sequestration of ammonia and primary amines rather than killing. The acidity claim appears only in popular sources and in no measured form for a dressing. No controlled clinical trial was found, and Varley and Barnett's 1987 paper in *Clinical Rehabilitation*, the clinical reference most often cited, could not be located in two searches [VERIFY].

Identification is easy at genus level. Sphagnum has a body plan no other moss shares: a stem bearing leafy branches in clusters of three to six, the young branches packed into a head called the capitulum, and leaves showing under a lens narrow green cells around large empty clear cells with pores. *S. papillosum* is pale ochre-brown, never with any trace of red, with short blunt-ended branches. *S. palustre* forms large untidy hummocks with hooded concave branch leaves and a wide pale stem cortex (British Bryological Society, n.d., Community Wetlands Forum 2024). Confusion is with other bog mosses, not with a dangerous plant. Fifteen species occur on a lowland raised bog and the published beginner's guide warns it is by no means foolproof, so learn the genus and let the species go. Harvest sustainably: leaving 30 per cent of the harvestable moss gave 90 per cent cover again after three years in a New Zealand study, and Tasmanian guidance is to retain about 30 per cent, spread loose tendrils over bare patches and allow 5 to 10 years before reharvesting (Whinam and Buxton, via Tasmania NRE, n.d.).

**The bandage roll and the triangle.** Roller bandages are cut on the straight grain from washed, boiled cotton or linen, about 2.5, 5, 7.5 and 10 cm wide and about 4 m long. The modern triangular bandage has a base of about one metre (Bourbaki Panorama, n.d.). The nineteenth-century Esmarch pattern was larger, a base of 4 feet and sides of 2 feet 10 inches, about 122 by 86 cm (Ingenium Canada, n.d.). Cut to the Esmarch size, since a large triangle folds down and a small one does not fold up. One square metre cut corner to corner gives two bandages.

### 1.9 Plaster, splints, tubes, syringes and the listening instruments

**Plaster of Paris.** Antonius Mathijsen, a Dutch army surgeon at Haarlem, rubbed dry plaster into coarsely woven linen and moistened it as it was applied, publishing in *Repertorium* in February 1852. Before this, starch bandages took up to a day to harden (Open Orthopaedics Journal 2017). The chemistry is gypsum driven to the hemihydrate by heat. A study of Brazilian gypsum found complete conversion to beta-hemihydrate at 180 °C for 2 hours and only partial conversion at 160 °C. A ceramics thesis reported hemihydrate at 148.5 °C for 2.2 hours, a dental materials lecture gives 110 to 130 °C, and commercial sources give 140 to 180 °C with a warning that excess heat produces dead-burned anhydrite that will not set. The sources disagree and none is a medical specification [VERIFY]. The safe reading is to calcine between 150 and 170 °C for about two hours and test a sample before making bandages. Unmodified plaster begins to set about 10 minutes after mixing and is hard in about 45, though the cast is not dry for 72 hours.

**Splints.** No source read gives a clinical standard for splint length or padding, which is itself a finding. Training material is consistent on principle. Immobilise the joints above and below the injury, splint a joint in the position

found unless the limb beyond is cyanotic or pulseless, pad every void, do not wrap tightly, and leave fingers or toes exposed (UCSF 2017, Geneseo EMS 2016). Check intervals disagree, one source giving 15 minutes and another about an hour. Splint woods want to be light, straight-grained and knot-free, which in temperate Europe means willow, poplar, lime and spruce, riven rather than sawn, but no source read names species, so this is inference [VERIFY].

**Tubes and catheters.** There is no village substitute. King gives sizes: Ryle's nasogastric Ch14 to Ch18, with the first marking at 45 cm showing the tip is about to enter the stomach, and stomach tubes Ch8 to Ch22, adults taking Ch16 to Ch22, children Ch10 to Ch14 and infants Ch8 to Ch10. For chest drainage the improvisation literature is thin. A registered observational study in conflict zones is comparing standard drains with nasogastric tubes and drip sets adapted as underwater seals (NCT06683976, registration only, no results). Two newborns in Guinea with tension pneumothorax were managed with a seal improvised from a plastic infusion bottle and a Heimlich valve improvised from a Vicryl fingerstall, and both worked (case series, abstract). One group reported a Foley-type catheter with the balloon inflated for pleural effusion across 3,500 catheters in 10 years, but that is elective fluid drainage, not trauma. There is no case series of a Foley as a trauma chest drain. Salvage chest drains and underwater seal sets specifically.

**Syringes.** Pravaz's 1853 instrument was silver, 3 cm long and 5 mm across, advanced by a screw, and Wood's, the same year, used glass so the volume could be seen. Hermann Wülfing-Lüer produced the graduated all-glass syringe in Paris in 1894, heat resistant enough to autoclave at 120 °C (LITFL, n.d., National Museums Scotland, n.d.). Glass syringes were boiled, steamed or autoclaved between patients, and without an autoclave the common method was steam above boiling water for at least 10 to 20 minutes. The harm from getting this wrong is the largest body count in this report. Contaminated injections were estimated to cause 21 million hepatitis B, 2 million hepatitis C and 260,000 HIV infections worldwide in the year 2000, and in Elista in 1988 and 1989 children were infected with HIV because staff changed the needle and reused the syringe, into which blood flows back (THRIVING library, WO-12).

**Stethoscope and thermometer.** The stethoscope is the one instrument a village can make on the first day. Laennec in 1816 rolled a sheaf of paper, then turned a wooden cylinder. Reported dimensions conflict, at 25 cm by 2.5 cm in one account, 12 inches by 1.5 inches with a 3/8 inch bore in another, and museum examples at 31 cm and 36 cm (BSHM, n.d., EMS Museum, n.d., RCPSG collection, n.d.). The construction that recurs is a turned hardwood cylinder with an axial bore, one end hollowed into a funnel, with a removable plug carrying a narrow tube for the heart and the cylinder used without the plug for the lungs. A Pinard horn for fetal heart sounds is a cone about 200 mm long, but the only source found for that figure is low quality [VERIFY].

The thermometer is the opposite. It depends on a fine uniform capillary bore and a constriction to hold the reading, which Aitkin introduced in 1852. Allbutt's 6-inch instrument of 1866 recorded a temperature in 5 minutes against the 20 minutes of the foot-long models it replaced, and Wunderlich published more than a million axillary readings from more than 25,000 patients in 1868, reporting a normal range of 36.3 to 37.5 °C (clinical thermometry review, search summary). Drawing capillary tubing of even bore and calibrating it is glassworking of a high order, and no source read describes a village method. Thermometers are salvage, they are fragile, and every one belongs in a padded case. A healer who loses them all is back to the hand on the forehead, which detects fever poorly and must not be used to decide anything that depends on a number.

## 2. Evidence grades

| Item or practice | Grade | Basis |
|---|---|---|
| Standardised minimum set (ICRC, MSF, WHO, King) | B | Four independent lists converge, long field use, no trials |
| Solid forged resharpenable scalpel | B | Named in King, and all surgery before 1915 |
| Smith-made scalpel, retractors, probes, straight needles | C | Metallurgy sound, no clinical series |

| Item or practice | Grade | Basis |
|---|---|---|
| Smith-made ratcheted haemostats and needle holders | D | No source shows a village forge making these in number |
| Tungsten carbide needle holder | B | King, twice the cost, more than twice the life |
| Resharpening needles and scalpels on a stone | B | King's instruction, universal pre-1950 practice |
| Resharpened blade equal to new for healing | D | Indirect animal data only, no comparative study |
| Hypodermic needle crimped onto monofilament | C | King after Remis 1983, sizing table, no outcome data |
| Fishing line matched to USP size | C | King's table, WO-03 cautions on additives and knots |
| Linen or cotton thread as suture and ligature | B | King, with a named case |
| Silk from cocoons as suture | B | Halsted's series, measured tenacity, steam sterilisable |
| Home-cured catgut buried in tissue | X | Edinburgh 1920s tetanus cluster, 11 of 11 cases |
| Commercial catgut under controlled manufacture | B | Long clinical record, unpredictable absorption |
| Sealed salvaged suture 12 to 24 months past expiry | C | King's figure, single source, conflicts with WO-03 |
| Boiled, ironed linen dressings, steam sterilised | B | Hospital practice to the 1950s, WO-12 data |
| Degreased and bleached cotton wool | B | Strutt 1879, Gamgee 1880, mechanism understood |
| Sphagnum as an absorbent dressing | C | Mass wartime use, no trial |
| Sphagnum as an antiseptic | D | Pure-culture work only, no measured dressing pH |
| Plaster of Paris bandage | B | Mathijsen 1852 onward, universal use |
| Village calcination of gypsum to a reliable hemihydrate | D | Published temperatures conflict by 70 degrees |
| Splinting the joints above and below, padded | C | Consistent training guidance, no comparative trials |
| Improvised chest drain | D | Two neonates, one air-ambulance case, one unreported trial |
| Reuse of resterilised single-use devices | C | Pacemaker cohort, 1,051 patients, 2.0 against 1.2 per cent |
| Reuse of a syringe between patients | X | 21 million HBV, 2 million HCV, 260,000 HIV in 2000 |
| Wooden monaural stethoscope | B | Laennec 1816 onward, a century of chest medicine |
| Village-made clinical thermometer | D | No source describes a feasible method |

## 3. Means ledger

| Rung | Instruments | Sutures and needles | Dressings and splints | What it changes |
|---|---|---|---|---|
| Hands and knowledge | A sharpened flake or a clean knife, fingers as retractors | None, pressure and strips of cloth | Clean cloth, a limb bound to the body or a stick | Bleeding stopped by pressure, no deliberate cutting |
| Hearth | Kitchen knife reground, sewing needle, pliers, boiled | Linen or cotton thread on a sewing needle, silk if kept | Boiled, dried, ironed linen, cotton rag, a triangle | Skin closure, abscess drainage, splinting. Spores survive boiling |
| Garden and still | Forged scalpel, retractors, probes, elevators, crude scissors, oilstone | Forged needles, reeled silk, monofilament resterilised | Degreased cotton wool, sphagnum pads, calcined plaster, splint boards | True sterilisation at 121 °C, a resharpening cycle, real casts |
| Village dispensary (300) | Full MSF-grade set, 6 to 12 haemostats, 2 needle holders, scissors, retractors | Salvaged sutures, improvised swaged needles, 12 eyed needles | Sterile dressing drums, bandage rolls, a plaster store | Haemostasis under direct vision. Operations beyond skin become possible |
| District infirmary (3,000) | Two full sets, abdominal retractors, bone and dental instruments, chest drains | Graded sutures 3/0 to 1, atraumatic where salvaged, steel wire | Textile pack sterilising, plaster room, traction | Laparotomy, amputation, caesarean section, chest drainage |
| Hospital before the Fall | Disposable blades, powered reprocessing, single-use everything | Swaged synthetic absorbables with validated profiles | Manufactured sterile dressings, synthetic casting tape | A new sterile instrument every time. The failure mode disappears |

## 4. Harm test

**The blunt scalpel.** A blunt blade does not cut, it tears and crushes. Rough irregular edges cause shear stress, tearing, uneven margins and increased inflammation, while smoother edges give less bleeding and less scar (MDPI 2025). The practical harm is worse than the histology. A healer pressing harder loses control of depth, and the blade goes through the structure beneath. The sign is that the skin dimples before it parts. Stop, strop or restone the blade, and never finish a cut by force.

**The unsterile suture.** Eleven cases of suspected or confirmed post-operative tetanus at the Royal Infirmary of Edinburgh in the 1920s all had catgut. A 1936 Ministry of Health memorandum described nine post-operative tetanus cases, five fatal, pointing at home-cured catgut (THRIVING library, WO-03). Any thread buried in tissue is a foreign body that bacteria colonise and antibodies cannot reach. The error that harms is burying any home-made thread, and the dose is one stitch. Nobody should receive it in deep tissue until there is a way to test sterility. Signs it is going wrong are pain increasing after the first day, spreading redness, pus, a stitch cutting through, and fever. Then remove the stitches, open the wound, wash it with plenty of water, dress and change daily.

**The rusting needle and instrument.** Pitting gives bacteria a surface cleaning cannot reach, and a pitted ratchet seizes. The causes are chloride and moisture. The errors that harm are storing carbon-steel instruments sterilised

inside damp cloth packs, rinsing in hard or softened water, leaving blood to dry, and autoclaving instruments closed. Signs are brown staining, a ratchet that catches, a scissor that will not close smoothly. Then withdraw the instrument, clean, de-rust, re-polish and re-oil, and discard anything pitted on a working surface.

**The reused syringe.** The worst single error in the book. Changing the needle does not make the syringe safe, because blood flows back into the barrel, which is how children in Elista were infected with HIV in 1988 and 1989. Hepatitis B survives at least 7 days dried on a surface (THRIVING library, WO-12). Nobody is exempt.

**The improvised chest drain.** Placing a tube wrong kills quickly, through the diaphragm into the liver or spleen, into the lung, or through an intercostal vessel. A tube too soft kinks and stops draining, turning a drained pneumothorax back into a tension pneumothorax with no outward sign but deterioration. The sign is breathlessness and falling blood pressure after an initial improvement, with no bubbling or swinging in the seal.

**Plaster.** A circumferential cast over a fresh wound or a swelling limb causes compartment syndrome and the limb is lost (THRIVING library, WO-03). Signs are pain out of proportion, pain on passive stretch, numbness, a cold or pulseless limb. Split the cast along its whole length at once, down to skin, and open the padding. Setting plaster is also exothermic, and a thick cast over too little padding can scald.

**Sharp retractors.** King's caution about the Volkmann rake, that its teeth are like a cat's paw and will injure anything important, applies to every sharp retractor pulled blind.

**Who must never receive what.** Anything buried in a pregnant uterus or in bowel must be absorbable and known-sterile, so after the Fall it must be salvaged, not made. Infants take the smallest tubes, Ch8 to Ch10, and an adult nasogastric tube passed into an infant can enter the trachea. The old and the dehydrated have fragile skin, and a tight bandage or too-tight stitch necroses it within a day.

## 5. Red flags

- **Bleeding that will not stop with pressure and cannot be clamped**, because there is no haemostat. Pack the wound hard with sterile cloth, apply a tourniquet high on a limb and note the time, raise the limb. If the vessel is in the abdomen or chest, accept that the patient will die and stay with them.
- **Tension pneumothorax with no chest drain and no large needle.** Breathlessness, a silent chest on one side, distended neck veins, falling pressure. This kills in minutes.
- **A fracture with a cold, pulseless or insensate limb** that does not correct with gentle alignment and splinting. The limb will be lost without vascular surgery.
- **Compartment syndrome** after a crush or a cast. Without fasciotomy the muscle dies, and splitting a cast buys hours only.
- **A deep soil-contaminated wound in an unimmunised person** who then develops trismus or spasm. Tetanus without antitoxin and ventilation is almost always fatal, so the answer is prevention: no buried home-made thread and no closed dirty wound.
- **Gas gangrene**, which needs excision to healthy bleeding contracting muscle, or amputation at district level (THRIVING library, WO-03).
- **Obstructed labour needing caesarean section** with no instruments and nobody trained. Both will die.
- **A fever that must be measured and cannot be**, because the thermometers are gone and the decision depends on the number.

In every one of these the thing to do anyway is the same. Clean water, clean cloth, a quiet place, pain relief if there is any, the truth, and someone sitting with the patient. A healer who can do nothing else can still do that.

## 6. The case against

**Craft sources overstate the forge.** This is the strongest criticism and it is justified. Bladesmithing writing makes a hardened blade look like an afternoon's work, and it is, for someone with a belt grinder, a thermometer, quench oil and a decade of practice. The honest claim is narrow. A competent smith can make a scalpel, a retractor and a needle, and cannot make a ratcheted box-jointed haemostat in quantity. A critic would add that even the scalpel claim is untested, since no modern source describes a village-forged scalpel used in surgery and followed up.

**The sphagnum literature will not bear the weight put on it.** Published absorbency figures range from twice to thirty times in two incompatible units, and the clinical paper most often cited could not be located. The antibacterial mechanism rests on pure-culture work on an extracted polysaccharide, not on a dressing. The wartime record proves that an enormous quantity was made and used, not that it beat what it replaced, and it replaced cotton because cotton was needed for explosives. A critic would say a village with linen should boil and iron linen, and gather moss only when the linen runs out.

**King is a single voice on several load-bearing claims.** The 12 to 24 month post-expiry figure, the fishing-line gauge table and the crimped hypodermic needle all come from one manual and are not corroborated here, and WO-03 is more cautious about fishing line. A critic would note that the manual was written for a doctor in a district hospital with a supply chain, and assumes judgement a lay healer does not have.

**The romance of the hospital.** The lists in section 1.1 are what the humanitarian system buys, not what evidence says is needed. No trial compares a 25-instrument set with a 9-instrument set for outcomes, and the lists converge partly because they copy one another: the WHO list states that it was compiled from WHO's own district hospital manual and three other WHO documents.

**The romance of the herbal.** Ant heads, thorns and plant gums as closures have been repeated far more often than they have been observed (THRIVING library, WO-03). Moss, honey and spider web carry the same risk of being quoted because they are charming.

**The case for salvage over manufacture.** A critic could argue this report spends too long on making things. One clinic's stock of haemostats, needle holders, catheters and blades would equip a district for twenty years, and the forge's effort is better spent on scythes, hoes and nails. The answer is that salvage is finite and dated, and the first generation after the Fall is the only one that can choose. Named critics could not be found for most of these positions, because a literature on post-collapse instrument making does not exist. Kenneth Iserson's *Improvised Medicine* is the nearest published counterweight and could not be read for this report.

## 7. Ten-line summary

1. Four independent minimum instrument lists converge on nine things: a blade, scissors, toothed and plain forceps, six artery forceps, a needle holder, needles, thread and retractors.
2. A smith can make a scalpel, retractors, probes and needles, and cannot make ratcheted haemostats and needle holders in number, so those are the first salvage.
3. ASTM F899 puts a surgical blade at about 58 HRC, the same target a bladesmith already works to.
4. Carbon steel must be oiled after every use and never stored sterilised in damp cloth packs.
5. A hard oilstone and the habit of using it is worth more than a second set of instruments.
6. A hypodermic needle crimped onto monofilament makes an atraumatic needle, turning the most salvageable item in a clinic into sutures.
7. Linen and cotton thread knot well, can be cut 2 mm from the knot, and have closed a human abdomen in a village.
8. Home-cured catgut buried in tissue caused a tetanus cluster in Edinburgh in the 1920s and is graded X.
9. Boiled, dried, ironed linen, steam sterilised and stored dry for not more than four weeks, is a complete dressing system and was hospital practice within living memory.

10. One sterile needle and one sterile syringe, for each person, for each injection, with no exceptions.

## 8. Open questions

- Is a resharpened scalpel blade equal to a new one for infection and healing? No study found.
- How long does sealed salvaged suture actually keep? King says 12 to 24 months past expiry. Nothing corroborates it, and nothing addresses twenty years.
- What is sphagnum's absorbency in grams of fluid per gram of dry moss, measured once, properly? The published range is 2 to 30.
- What is the pH at the surface of a sphagnum dressing against a wound? No measurement found.
- Can a village forge produce a usable ratchet and box joint, and at what hours per instrument? No source attempts it.
- What temperature and time calcines gypsum to a cast-grade hemihydrate at village scale? Published figures span 110 to 180 °C.
- What is the failure rate of an improvised chest drain in trauma? One registered trial, no results.
- Does degreasing raw cotton with wood-ash lye at household scale work, and in what proportions?
- Which splint woods, by species, give the best stiffness for weight, and at what thickness?
- Can a village make a clinical thermometer at all, or is fever measurement simply lost?

## 9. Sources to read in full

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6. Bishop WJ, *A History of Surgical Dressings* (1959). The primary history behind every secondary account of lint, charpie and cotton wool.
7. Cathcart CW's 1915 *British Medical Journal* paper on sphagnum, and Varley and Barnett (1987) in *Clinical Rehabilitation*. Neither could be read, and the sphagnum question cannot be settled without them.
8. ASTM F899, Standard Specification for Wrought Stainless Steels for Surgical Instruments, for the heat treatment tables.

## 10. At the bedside after the Fall

**A household.** The minimum is a sharp knife that is actually sharp, a fine oilstone, a sewing needle, linen thread, a pot that boils, and a store of boiled, dried, ironed linen in a lidded tin. With those a household can clean a wound, close a clean cut in skin, drain an abscess, dress a burn and splint a limb. What it needs to start: cloth, a stone, fire, and the knowledge that needle and thread must be baked or steamed and not merely rinsed. First failure to expect: the knife goes blunt without anyone noticing, because a blunt knife feels normal to the hand that has been using it. Test it sideways on the thumb, every time.

**A village of 300.** The minimum is one MSF-grade set: scalpel handles and a box of blades, two scissors, a toothed and a plain dissecting forceps, six to twelve artery forceps, one carbide needle holder, four towel clips, two retractors, a kidney dish and a sterilising container, plus twelve eyed needles, reels of silk or linen and monofilament, a pressure

cooker, a hard oilstone and a stock of dressings. What it needs to start: a salvage expedition to the nearest clinic, veterinary practice or dental surgery before the buildings are stripped, one person trained to clean, sharpen, sterilise and keep a written instrument register, and a dry lockable store. First failure to expect: the register is not kept, instruments are lost one at a time, and in five years nobody can say how many haemostats the village owns.

**A district of 3,000.** Two full sets so one sterilises while the other works, plus abdominal retractors, bone instruments, dental forceps and elevators, chest drains and underwater seals, catheters and nasogastric tubes in a range of sizes, glass syringes and needles of every gauge, a plaster store, a working steam steriliser with a maintenance plan, and a smith given instrument work as a standing job. What it needs to start: the salvage list in section 1.3 worked through while transport still exists, and a written inventory copied and kept in two places. First failure to expect: the autoclave breaks and cannot be repaired. Half the sterilisers in the poorest hospitals today already do not work. Plan for the pressure cooker from the first day, not the last.

## 11. Protocols

### Protocol 1. The salvage run

1. Go to clinics, veterinary practices, dental surgeries and ambulance stations, in that order. Veterinary and dental premises are less likely to be stripped and hold the same steel.
2. Take first, in order: carbide needle holders, artery forceps, scissors, scalpel handles and whole boxes of blades, eyed needles, sealed sutures, catheters and tubes, syringes and hypodermic needles of every gauge, dental forceps and elevators.
3. Take all sealed sutures regardless of expiry date, and mark the date on each box.
4. Take sterilising baskets and drums, autoclave tape, chemical indicators and service manuals.
5. Take the oilstones, pliers, wire and sheet copper.
6. Record everything in one register, in ink, with a copy in a second building.

### Protocol 2. Daily care of instruments

1. Wipe or rinse off blood immediately. Do not let it dry. Keep water below 60 °C.
2. Open every hinge and ratchet. Scrub with soap and a soft brush. Clean box joints with a stick.
3. Rinse finally in rainwater, or boiled water allowed to settle. Avoid hard and softened water.
4. Dry completely, at once, with a clean cloth and then in air.
5. Oil carbon steel with a thin film after every use. Stainless needs no oil but tolerates it.
6. Store dry, open, unwrapped, in a closed box. Never store carbon steel sterilised in a cloth pack.
7. Inspect weekly for staining, pitting, a ratchet that catches, a scissor that will not close to the tip. Withdraw anything pitted on a working surface.

### Protocol 3. Sharpening

1. For a blade that still cuts, use the fine stone only. For a very blunt blade, start on coarse carborundum.
2. Wet the stone. Hold the scalpel at 15 to 17 degrees a side, about two coins' thickness under the spine of a 30 mm blade.
3. Work one side until a burr can be felt along the whole edge with the thumb drawn sideways across it, never along it. Then work the other side until the burr moves back.
4. Alternate with lighter strokes, about ten each side, then five, then two, until the burr falls off.
5. Strop on plain leather, edge trailing, twenty strokes each side.
6. Test. The edge should catch the thumb at once and part a hanging thread.
7. For scissors, grind only the outer bevel of each blade, following the existing angle, and never touch the inner faces. Oil the joint.

8. For a cutting needle, draw the three cutting edges across the fine stone a few strokes each, keeping the triangular section, and check it pierces a scrap of leather cleanly.

**Protocol 4. Making a needle at the forge**

1. Stock: high-carbon wire or rod, about 0.6 to 1.0 mm for a medium needle.
2. Flatten the eye end over about 4 mm, drift the eye, and file it smooth inside, because a rough eye cuts the thread.
3. Draw and file the point. For a cutting needle file three flats to a triangle, edge on the inside of the curve.
4. Form the curve over a round mandrel, to three-eighths or half a circle, before hardening.
5. Harden from just past the magnet, about 800 °C, quenching in oil.
6. Temper at once at 200 °C for two hours, twice, to light straw.
7. Test. It must flex and spring back, and must not snap when gripped by a needle holder. One that snaps was left too hard. One that stays bent was left too soft.
8. Polish bright, oil, and store dry in a stoppered wooden tube.

**Protocol 5. A swaged needle from a hypodermic needle**

1. Match gauge to thread. USP 3-0 takes 23, 24 or 25 gauge, 2-0 takes 22, 0 takes 20 or 22, and 1 takes 20.
2. Thread the monofilament through the needle from the hub end until it emerges at the point.
3. Snap off the plastic Luer hub.
4. Withdraw the thread back into the metal so it does not project at the hub end.
5. Crimp the metal tightly onto the thread with pliers, about 3 mm from the cut end. Pull hard to test. It must not come out.
6. Bend the needle to the curve wanted, over a round former.
7. Sterilise by dry heat at 170 °C for 1 hour or 150 °C for 2.5 hours, or by steam at 121 °C for 20 minutes unwrapped (THRIVING library, WO-12). Pull a test length to destruction to check the thread has not gone brittle.

**Protocol 6. Matching fishing line to suture size**

King's table, the practical core of improvised suture (King et al. 2011).

| USP size | Diameter (mm) | Line breaking strength | Typical use |
|---|---|---|---|
| 5-0 | 0.100 to 0.149 | 1 lb | Face, neck, vessels |
| 4-0 | 0.150 to 0.199 | 2 to 4 lb | Neck, hands, limbs, tendons |
| 3-0 | 0.200 to 0.249 | 6 lb | Limbs, trunk, bowel |
| 2-0 | 0.300 to 0.339 | 8 to 10 lb | Trunk, fascia, viscera |
| 0 | 0.350 to 0.399 | 12 to 14 lb | Abdominal wall, fascia, muscle |
| 1 | 0.400 to 0.499 | 15 to 20 lb | Abdominal wall, bone |
| 2 | 0.500 to 0.599 | 25 to 30 lb | Heavy tension sutures |

Tolerances and cautions. The thickness of fishing line is not necessarily proportional to its breaking strength, so measure the diameter if a gauge exists. A good strength for abdominal closure is 12 to 20 lb. Never grip monofilament with artery forceps or a needle holder. Tie a surgeon's knot with two or more turns on each of the first two hitches and one on the third, and leave tails longer than 5 mm.

**Protocol 7. Making dressings**

1. Choose plain woven linen or close-woven cotton. Wash it clean of soap.

2. Boil 20 minutes, rinse in clean water, dry fully in sun or by fire.
3. Iron both sides. The purpose is a smooth lint-free surface, not sterility.
4. Tear along the grain rather than cutting where possible, which leaves fewer loose fibres. Fold cut edges inward.
5. Sizes: squares of 10 by 10 cm for most wounds, 20 by 20 cm for large ones, pads of eight to twelve folded layers for bleeding.
6. Roller bandages: strips on the straight grain, 2.5, 5, 7.5 and 10 cm wide, about 4 m long, rolled tightly from one end.
7. Triangular bandage: from a square of cloth one metre on each side, cut corner to corner, giving two. The Esmarch pattern is larger, a base of about 122 cm and sides of about 86 cm.
8. Pack into a lidded tin, double-wrapped in cotton. Steam at 121 °C for 30 minutes. Dry with the lid ajar for 30 minutes or more. Discard any damp pack.
9. Label with the date. Use within four weeks. Discard if wet, torn or dropped (THRIVING library, WO-12).

**Protocol 8. Gathering and preparing sphagnum**

1. Identify the genus, not the species. A dense head of packed branches (the capitulum), branches in clusters of three to six along the stem, and leaves showing under a lens large clear empty cells with pores between narrow green ones.
2. Harvest only the living upper growth. Leave at least 30 per cent of the harvestable moss and spread loose tendrils over bare patches. Do not return to the same patch for 5 to 10 years.
3. Pick out every twig, leaf, insect and fragment of other moss by hand, on a table, in good light. This is the slow step and the one that gets skipped.
4. Dry thoroughly, in sun or over a low fire, until it crackles. Damp moss moulds.
5. Fill thin muslin or loose-woven cotton bags to a flat pad about 2 cm thick, and quilt with a few stitches so the moss cannot shift.
6. Steam at 121 °C for 30 minutes as a textile pack, dry, and store as in Protocol 7.
7. Use as the absorbent outer layer over a clean dressing next to the wound, not against the wound itself. Change when saturated, which will be sooner than the popular figures suggest.

**Protocol 9. Plaster bandages**

1. Break gypsum rock or set plaster waste to fist size, then to gravel.
2. Calcine at 150 to 170 °C for about two hours. A bread oven after the loaves come out is roughly this. Too hot gives dead-burned plaster that will not set.
3. Grind fine and sieve through cloth.
4. Test a handful. Mixed one part water to two parts plaster by volume, it should begin to stiffen at about 10 minutes and be hard at 45. If it never sets, it was burned too hot. If it sets in two minutes, it was underburned or has absorbed moisture.
5. Rub the dry powder thoroughly into coarse open-woven linen or gauze. Roll loosely. Store absolutely dry.
6. Apply over at least three layers of padding, more over bony points. Dip the roll, squeeze gently, apply without tension, and rub each layer into the one below with the flat of the hand.
7. Never close a cast completely over a fresh wound or a swelling limb. Split it along its whole length, down to skin, and leave the split open.
8. Watch for 48 hours. Pain out of proportion, pain on passive stretch of the fingers or toes, numbness or coldness means split or remove the cast at once.

**Protocol 10. The wooden stethoscope**

1. Take a straight-grained hardwood billet, beech, cherry or boxwood, about 30 cm long and 4 cm across.
2. Bore an axial hole of about 9 mm through its length with a long auger, or turn two halves and glue.

3. Hollow one end into a funnel about 3.5 cm across at the mouth and 3 cm deep.
4. Turn the other end flat and smooth, with a slight dish for the ear.
5. Make a removable plug for the funnel carrying a short narrow tube. Use the cylinder with the plug for the heart and without it for the lungs.
6. Oil the wood. Do not varnish the ear end.
7. Test it against a known heartbeat before trusting it on a patient.

## 12. Numbers to carry

1. **Nine instruments** are the core of every published minimum set: blade, scissors, toothed forceps, plain forceps, six artery forceps, needle holder, needles, thread, retractors.
2. **58 to 60 HRC** is a surgical cutting edge, reached by tempering a quenched blade at about 200 °C for two hours, twice, to light straw. Never temper between 230 and 315 °C.
3. **15 to 17 degrees a side** is the bevel of a scalpel on the stone.
4. **Twelve eyed needles** served a Civil War surgeon for a campaign, and a Keith straight needle may last a year with sharpening.
5. **12 to 20 lb** breaking strength is the fishing line for closing an abdomen, which is USP 0 to 1.
6. **Plain catgut holds 10 days, chromic about 20**, and either can be gone in 2 to 3 days in a septic wound.
7. **Four throws, two turns on each of the first two** for monofilament, with tails longer than 5 mm when the thread knots badly.
8. **121 °C for 30 minutes** for a textile pack, dried, double-wrapped, used within four weeks.
9. **170 °C for 1 hour** dry heat for needles and thread.
10. **One needle, one syringe, one person, one time.** No exceptions, ever.

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