WO-12 Sterile enough: boiling, pressure cookers, flame, alcohol, carbolic and the sterilisation ladder

HEALING after the FALL, research library, WO-12

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

1. Findings by section

1.1 Scope, and what this report does not repeat

This report covers how instruments, dressings, hands and rooms are made safe enough for the work in hand at each rung of the ledger: the ladder of clean, disinfected and sterile, what each method kills, the domestic pressure cooker as autoclave, and the discipline of the sterile field.

It leans on its neighbours. Semmelweis and handwashing belong to THRIVING library HY-01, soap and the hypochlorite table to HY-05, sutures and catgut to WO-03, and the earlier pressure-cooker note to FO-11. Wound antiseptics belong to IN-07, not yet written. WO-09, WO-15 and OR-07 did not exist when this was written, and WO-10 appeared during the work and was not read.

Under the series safety rule, carbolic acid, formaldehyde and other toxic agents get history, benefit, harm, dose and signs of poisoning only. Boiled water, steam, dry heat and chlorine diluted from a known bleach are given as recipes from two sources.

1.2 The ladder: clean, disinfected, sterile

Modern practice sorts every item by what it will touch. This is the Spaulding classification, used by the CDC and the WHO alike (Rutala et al. 2008, WHO 2016).

Rung	Definition	What it leaves alive	Items that need it
Clean	Visible soil, blood and most organisms removed by water, detergent or soap and friction	Many organisms, all spores	Non-critical items that touch intact skin: blood-pressure cuffs, bed frames, floors
Low or intermediate disinfection	Chemical or heat treatment that kills vegetative bacteria, most viruses and fungi	Spores, some viruses, mycobacteria at low level	Non-critical items, surfaces, the room

Rung	Definition	What it leaves alive	Items that need it
High-level disinfection	Kills all micro-organisms except some bacterial spores	Some spores	Semi-critical items that touch mucous membranes or broken skin: vaginal speculums, laryngoscope blades, some thermometers
Sterile	All life including spores destroyed, to a stated probability	Nothing, if the cycle worked	Critical items that enter sterile tissue or the bloodstream: scalpels, forceps, needles, syringes, suture, dressings for open wounds

The FP Handbook says high-level disinfection kills all organisms except some bacterial endospores (FP Handbook n.d.). WHO 2016 sets the rule plainly: critical items need sterilisation, semi-critical items need high-level disinfection, and non-critical items need cleaning (WHO 2016). It adds the sentence that should be painted on every dispensary wall: "If you cannot clean a device, you cannot sterilize it."

Cleaning removes the load, disinfection kills most of what remains, and sterilisation kills the hardest survivors, the bacterial spores. The agents of tetanus and gas gangrene live in soil as spores (THRIVING library, WO-03, on catgut tetanus), so what is good enough for a vaginal examination may not be good enough for an amputation.

1.3 History: from carbolic spray to steam

The record shows two stages. Antisepsis, in Lister's sense, kills germs in the wound with a chemical. Asepsis keeps them out by sterilising everything that touches the wound, mostly with heat.

Semmelweis. HY-01 covers him: maternal deaths in the Vienna first clinic fell from 11.4% to 1.27% after chlorinated hand washing began in 1847 (THRIVING library, HY-01). Nothing found here changes that account.

Lister and carbolic. Lister's 1870 figures from Glasgow Royal Infirmary gave 16 deaths in 35 amputations before antisepsis (about 45%) and 6 in 40 after (15%). He conceded the numbers were small. Hamilton later found hospital-wide mortality at Glasgow swinging between 0 to 30% and 65 to 75% over the period, so part of the improvement may track epidemic cycles. No parallel-group comparison was ever made. Lawson Tait reported 100 ovariotomies with 3 deaths without Listerism, and his results improved as he diluted the carbolic until he used plain boiled water by 1882. Bull in 1959 found Lister's difference statistically significant (Tröhler 2014, the last three points secondary through it).

Lister used carbolic at 1 in 20 for instruments, hands and skin, and 1 in 40 for other purposes (Lister carbolic article n.d., search summary). He abandoned the carbolic spray and told the Berlin congress of 1890 that he felt ashamed he should ever have recommended it for destroying the microbes of the air (The Hospital 1890, search summary). Carbolic poisoned patients. Surgeons described dark "smoky" urine on the second day and suppression of urine, children were especially susceptible, and a German report of 1884 described a five-year-old who died after carbolised gauze dressings (Carbolic poisoning article n.d., search summary).

Koch, Chamberland and steam. Koch, Gaffky and Löffler found in 1881 that live steam outperformed hot air, which needed about 160 °C held for long periods (secondary sources, [VERIFY] the original). Chamberland, in Pasteur's laboratory, built the steam pressure steriliser, the autoclave, in 1879 (Institut Pasteur n.d.).

Von Bergmann and Schimmelbusch. Ernst von Bergmann in Berlin moved to steam-sterilised dressings in 1886 and with Curt Schimmelbusch built the aseptic system shown at the Berlin congress of 1890. Schimmelbusch's handbook appeared in 1892 and in English in 1894 (Deutsche Biographie n.d., Wikipedia Schimmelbusch n.d.). Schlange, another of von Bergmann's assistants, showed that sublimate gauze worked because it was dry rather than because of the mercury [VERIFY, secondary]. Dry steamed gauze in a closed drum made the chemical unnecessary.

Halsted's gloves. In 1889 Caroline Hampton, Halsted's scrub nurse at Johns Hopkins, developed dermatitis from mercuric chloride and carbolic, and Halsted had the Goodyear company make thin rubber gloves for her. Their first written mention is in his 1891 paper on the treatment of wounds (Science History Institute n.d.). The gloves protected the nurse, not the patient. Bloodgood later reported infection in 38 of 220 hernia repairs without gloves (over 17%) against 4 of 226 with gloves (under 2%) [VERIFY: secondary only, and other changes in technique came at the same time].

Lane's no-touch technique. At Guy's Hospital in the 1890s William Arbuthnot Lane kept the surgeon's hand out of the wound. He used long instruments, kept his fingers several inches away, threaded needles with forceps, discarded the skin knife after the first cut and covered the skin edges with gauze (Wikipedia Lane n.d., secondary). The method was designed to work without reliable gloves.

The autoclave in the field. From 1985 UNICEF and WHO supplied a pressure-cooker-style steam steriliser for reusable immunisation syringes, made by Prestige Medical (Science Museum Group n.d.). A WHO study in Africa, reporting on a 1995 project, found that few health centres used time, steam and temperature indicators and that many boiled syringes instead of steaming them (Dicko et al. 2000, search summary).

1.4 What each method kills

The table separates what each method reliably achieves. The sources are the CDC guideline and its chemical tables (Rutala et al. 2008), WHO 2016 and WHO 2003, Hesperian 2023 and ICRC 2014.

Method	Conditions	Vegetative bacteria	Viruses incl. HBV, HIV	Mycobacteria	Bacterial spores	Rung reached
Boiling	100 °C at sea level, 20 min from a full boil	Yes	Yes	Yes	Not reliably	High-level disinfection
Steam under pressure, gravity	121 °C, 15 psi gauge, 30 min wrapped	Yes	Yes	Yes	Yes	Sterile
Steam, ICRC standard	134 °C, 2.1 bar gauge, 18 min	Yes	Yes	Yes	Yes	Sterile, with a prion margin
Dry heat	170 °C for 60 min, 160 °C for 120 min, 150 °C for 150 min	Yes	Yes	Yes	Yes, if the load reaches temperature	Sterile
Flame to red heat	Seconds, metal tip only	Yes, at the heated part	Yes, at the heated part	Yes	Probably, at the heated part [VERIFY]	Sterile tip only, no evidence base found

Method	Conditions	Vegetative bacteria	Viruses incl. HBV, HIV	Mycobacteria	Bacterial spores	Rung reached
Flaming with alcohol	Seconds of burning spirit	Partial	Partial	Partial	No	Not a method
70% alcohol	Wet contact, 60% to 90%	Yes	Most enveloped viruses, not hepatitis A or polio	Yes	No	Intermediate disinfection
Hypochlorite 0.5%	5,000 ppm, 10 min, clean surface	Yes	Yes	Yes	Yes, on clean surfaces	High-level disinfection, not a sterilant for instruments
Iodine and iodophors	Povidone-iodine solutions	Yes	Most	Yes	No	Intermediate
Phenol (carbolic)	Historical 2.5% to 5%	Yes	Some	Yes	No	Intermediate, toxic

Points behind the table:

Boiling. Hesperian tells community workers to boil or steam tools for 20 minutes, timed from a full boil, adding nothing once timing has started (Hesperian 2023, Conant and Fadem 2008). That is high-level disinfection. WHO 2016 lists boiling with glass bead sterilisers, microwaves and ultraviolet light as unacceptable methods of sterilisation, and WHO 2003 calls boiling unreliable and not for routine hospital use. The reason is spores. Home-canning advice says hours in a boiling-water bath will not destroy botulinum spores, which need 116 °C, about 10 psi at sea level (UGA Extension n.d., search summary). Teaching texts say some endospores survive many hours of boiling (OpenStax Microbiology n.d., search summary), and lecture notes claim some tetanus strains survive 15 to 90 minutes or more [VERIFY, lecture-note quality only]. Hepatitis B, by contrast, survived 98 °C for 1 minute but not 2 minutes in chimpanzee tests (HBV heat review 2020). Twenty minutes of boiling protects well against blood-borne viruses and poorly against the soil spores of tetanus and gas gangrene.

WO-03 and FO-11 carry "boil at least 10 minutes" from SY-03 (THRIVING library, WO-03). This report disagrees. Both community sources found say 20 minutes from the full boil, as does a Cameroon infection-prevention course (Doh 2007). Use 20.

Steam. Moist heat kills by coagulating proteins. The steam test organism, Geobacillus stearothermophilus, has a D-value (the time to kill 90%) of 1 to 2 minutes at 121 °C, and the steam should be at least 97% dry (Rutala et al. 2008). Fifteen minutes at 121 °C therefore gives roughly 7 to 15 tenfold reductions, if the steam reaches the spore. Sterilisation cannot occur in the presence of air (WHO 2016). Air trapped in a pot, a folded drape or a syringe barrel keeps the load cooler than the gauge suggests.

Dry heat. Dry heat kills by oxidation. The CDC gives 170 °C for 60 minutes, 160 °C for 120 minutes and 150 °C for 150 minutes (Rutala et al. 2008). WHO 2003 gives 1 to 2 hours at 170 °C and calls it "a poor alternative", for metal and some natural sutures only. A JSOM review gives WHO's figure as at least 2 hours at 170 °C, UNHCR's as 60 minutes at 170 °C and a special-forces handbook's as 60 minutes at 160 °C, and warns that ovens can be 30 to 40 °C off their setting. Time starts when the load, not the oven, reaches temperature (JSOM 2016). Hesperian says

to bake wrapped tools at "170°C (305°F) or higher for 2½ hours" (Hesperian 2023). The figures do not match: 170 °C is 338 °F, and 305 °F is about 152 °C. Read either way, 2.5 hours covers the CDC's 150 °C figure.

Alcohol. Alcohol works between 60% and 90%, loses activity sharply below 50%, does not kill spores and does not penetrate protein. The CDC records fatal postoperative Clostridium wound infections after instruments carrying spores were "disinfected" with alcohol (Rutala et al. 2008). WHO 2016 lists alcohol as a fixative of soil, and an ASM abstract of 2015 asked laboratories to stop wiping instruments with alcohol (ASM 2015). In 1940 Bigger reported sepsis from syringes disinfected with alcohol or ether (Mortimer 1995, abstract via search). Alcohol is for clean hands and clean skin.

Hypochlorite. The CDC records vegetative bacteria killed in seconds below 5 ppm, mycobacteria killed at about 1,000 ppm, and a million C. difficile spores inactivated by 5,000 ppm (0.5%) in 10 minutes or less. Blood and dirt inactivate it, it corrodes steel above about 500 ppm, and it gives off chlorine gas with acids or ammonia (Rutala et al. 2008). HY-05 gives the working strengths and the dilution rule, used unchanged here (THRIVING library, HY-05).

Iodine and phenol. Neither is sporicidal. Povidone-iodine solutions have been found contaminated with bacteria in the bottle, and phenolics caused jaundice in nursery infants and skin depigmentation in workers (Rutala et al. 2008). Neither belongs in instrument reprocessing after the Fall.

Flame. No authoritative source on flaming clinical instruments was found [VERIFY]. Laboratories heat wire loops to red heat, but burning spirit on a scalpel or forceps heats the surface briefly and unevenly and draws the temper of the steel. Flame is an emergency measure for a needle or lancet point only.

1.5 Cleaning first

Every source agrees: clean, then disinfect or sterilise. Hesperian says to take tools apart and scrub them with soap and a brush first (Hesperian 2023). WHO 2016 opens hinged instruments and keeps cleaning water below 60 °C, because proteins coagulate above it.

Here the two WHO manuals disagree. WHO 2003 told district hospitals to soak used instruments and needles in disinfectant, such as 0.5% chlorine, for 30 minutes before cleaning. WHO 2016 says this is not recommended: chlorine corrodes the steel, blood inactivates the chlorine, biofilm forms, and handlers are put at risk. The newer advice is to keep instruments moist and clean them promptly with water and detergent, wearing heavy gloves. This report follows WHO 2016, keeping a short chlorine soak only for sharps that must be handled with bare hands [VERIFY: inference].

1.6 The pressure cooker as autoclave

ICRC's guideline puts it in one line: "An autoclave is basically a large pressure cooker" (ICRC 2014).

What standard to aim for. ICRC sterilises all major-surgery instruments and linen at 134 °C, 2.1 bar gauge (3.1 bar absolute), for 18 minutes, a cycle chosen to meet the Swiss prion ordinance of 2002. Its 45-litre autoclave runs at 1.1 bar (121 °C) with the valve open and 2.1 bar (134 °C) with it closed (ICRC 2014). A domestic stovetop cooker at 15 psi (103 kPa) gauge reaches about 121 °C at sea level and cannot reach 2.1 bar. The realistic target after the Fall is 121 °C, held for the 121 °C time.

How long at 121 °C. The sources differ.

Source	Load	Time at 121 °C
CDC (Rutala et al. 2008)	Wrapped instruments, gravity displacement	30 min, dry 15 to 30 min

Source	Load	Time at 121 °C
CDC (Rutala et al. 2008)	Textile packs, gravity displacement	30 min, dry 15 min
WHO 2003	Unwrapped	20 min
WHO 2003	Wrapped packs	30 min
Hesperian 2023	Wrapped in 2 layers of crepe paper	20 min at 15 to 20 lb
Conant and Fadem 2008	Tools	20 min at 15 to 20 lb
WHO 2016, pot-style tabletop steriliser	Unwrapped instruments	Cycle about 16 min plus 10 min to depressurise
Cook et al. 2021	4-quart stovetop cooker, indicators in the load	20 min at 15 psi, all indicators passed

The disagreement is 20 against 30 minutes for wrapped loads. The 30-minute figure is the CDC's for gravity-displacement sterilisers, which is what a pressure cooker is, and WHO 2003's for packs. This report adopts 20 minutes for unwrapped metal and 30 minutes for anything wrapped, folded or porous. The extra 10 minutes costs fuel and buys margin against air pockets.

Does a kitchen cooker work? Cook and colleagues ran a 4-quart Presto stovetop cooker on one electric burner at 15 psi for 20 minutes, with 3M Attest biological indicators and Comply SteriGage integrators in the load. All 128 indicators passed. Time to pressure averaged 379 seconds (spread 77 seconds), and ambient conditions made no difference. The method is not FDA-approved (Cook et al. 2021, abstract only). Swenson and colleagues tested four 8-quart electric multicookers. Only the Instant Pot inactivated G. stearothermophilus ampoules, after at least 150 minutes, and the other three failed even at 300 minutes. Their makers gave 5.8 to 13 psi and 88 to 118 °C (Swenson et al. 2018). A stovetop cooker with a 15 psi weight works. An electric multicooker is not a steriliser.

Air removal. A cooker removes air by gravity: steam rises and pushes the heavier air out of the vent. ICRC's procedure for the UNICEF 39-litre pressure-cooker autoclave is to heat with the purge valve open until a continuous jet of steam appears, close it, rise to 2.1 bar, open the purge to drop to 0.2 bar, repeat twice more, and then hold 18 minutes (ICRC 2014). For a kitchen cooker the simple version is to let steam vent freely for a timed period before the weight goes on. Canning practice uses 10 minutes [VERIFY: not read in a source for this report].

Losing pressure unnoticed. Pressure falls when the heat drops, the water boils dry, the seal leaks or the vent blocks. Steady rocking of the weight, or the gauge needle, is the only sign. If it falls, restart the count from zero once pressure returns [VERIFY: inference, no source read gives the rule for cookers]. A blocked vent can make a cooker explode (THRIVING library, FO-11).

Altitude. The weight or gauge measures pressure above the surrounding air, so as the air thins the pot runs cooler. Atmospheric pressure is about 89.9 kPa at 1,000 m and 79.5 kPa at 2,000 m, where water boils at about 96.7 °C and 93.5 °C (calculate.co.nz n.d., search summary). Saturated steam is 118.6 °C at 190 kPa absolute and 123.3 °C at 220 kPa (Engineering ToolBox n.d.). A 15 psi cooker runs at about 205 kPa absolute at sea level, about 193 kPa (119 °C) at 1,000 m and about 183 kPa (117 °C) at 2,000 m [VERIFY: own calculation from the two sources]. Canning tables raise the pressure with height for this reason. Utah State's dial-gauge table rises by 1 psi per 2,000 ft from 11 psi to 15 psi at 10,000 ft, and uses the 15 psi weight above 1,000 ft (USU Extension n.d.). A sterilising cooker is already at 15 psi, so the correction must come from time. If spore killing slows tenfold for each 10 °C drop, a common assumption, a 4 °C shortfall multiplies the time by about 2.5 [VERIFY: assumption not sourced here]. Above 1,000 m, double the hold time. Above 2,000 m, treat a domestic cooker as uncertain without biological indicators [VERIFY].

Indicators. Autoclave tape changes colour on exposure but does not register time at temperature and can change early at low temperatures (US patent RE34515, search summary). ICRC uses TST strips that turn from yellow to dark blue only when time, steam and temperature are all met (ICRC 2014). UNICEF's TST control spot must

change irreversibly after at least 15 minutes in saturated steam at 121 °C (UNFPA n.d.). A 1979 test of 21 commercial steam indicators found 5 whose kinetics matched the spore indicator, and 3 of those overstated lethality (AEM 1979, search summary). Biological indicators are the only direct test (Rutala et al. 2008). The shelf life of salvaged indicators is unknown, and no improvised indicator was found in any source read [VERIFY].

Drying. Wet packs count as contaminated, because water wicks organisms through the wrap (WHO 2016), and WHO 2003 reads wet spots as a sign of failure. ICRC dries for 30 minutes or more with the lid ajar and discards damp packs (ICRC 2014). Let the cooker fall to zero, open the lid a crack, let the load dry in its own heat, and handle packs only when cool and dry.

1.7 Cloth and dressings

Steam is the standard for dressings and drapes because it penetrates folded cloth without scorching it. The CDC gives 30 minutes at 121 °C for textile packs in a gravity steriliser (Rutala et al. 2008). ICRC sterilises linen double-wrapped in crepe paper at 134 °C for 18 minutes, never mixes linen and instruments in one load, fills its 39-litre cooker to no more than 75% with a hand's width between packs, and lays a towel over the load to catch drips (ICRC 2014).

Baking cloth is a poor alternative. One search summary put 60 minutes of dry heat at 160 °C as roughly equal to 15 minutes of steam at 120 °C, and cotton and paper scorch at not much more [VERIFY: about 180 °C, search summary]. Hesperian's baking instruction wraps tools in four layers of cloth or paper (Hesperian 2023), so the wrap survives if the oven runs near 150 to 170 °C.

Blood-soiled linen is washed cool first, then in dilute chlorine, then with detergent at 71 °C or more for 25 minutes (WHO 2003). HY-05 gives the laundry standard of 65 °C for 10 minutes or 71 °C for 3 minutes (THRIVING library, HY-05). Both are disinfection of linen, not sterilisation of dressings.

1.8 Storage of sterile goods

Sterility is event-related. A pack stays sterile until something happens to it: it gets wet, torn or dropped, or someone opens it (Rutala et al. 2008, WHO 2016). WHO 2016 asks for a dry, ventilated store at 15 to 25 °C and 40% to 50% relative humidity, first in, first out, with as little handling as possible. ICRC cools packs on a wire rack, stores them in lidded plastic boxes away from dust, humidity and sun, checks them weekly, and gives double-wrapped crepe or non-woven packs a maximum of 4 weeks (ICRC 2014).

Cotton wraps last longer than once feared. A Thai study of laundered cotton wraps used up to 50 times found contamination only sporadically, at the 30th and 50th launderings, and suggested a shelf life of at least 60 days against a local standard of 14 days (Apinhapath and Jongpremkijpaisan n.d.). After the Fall, double cotton wrapping, dry storage in a closed box and a four-week limit are a defensible rule.

Unwrapped instruments do not stay sterile once taken out of the steriliser (WHO 2016). They must be used at once or kept in the closed, still-hot cooker until needed.

1.9 The sterile field

A sterile field is an area where every item is sterile and everyone who reaches into it is scrubbed and gloved or using instruments only. It is behaviour more than equipment. The sources read give the materials but few give the rules as a lay list. The rules below draw on WHO 2003, WHO 2016 and general theatre practice, and those marked [VERIFY] are not from a source read for this report.

1. Sterile touches only sterile. If in doubt, it is not sterile (Rutala et al. 2008, event-related sterility).
2. Only the top of a draped table is sterile, not the edges that hang over [VERIFY].
3. Hands stay above the waist and in sight. Nobody reaches across the field from outside or turns their back on it [VERIFY].

4. Packs open away from the body first, so the outside of the wrap never crosses the inside [VERIFY].
5. Wet drapes are unsterile, because moisture wicks through (WHO 2016, by extension).
6. One person watches and calls contamination at once. The item is replaced, not argued about [VERIFY].
7. Lane's rule: neither the wound nor the working end of an instrument is touched by hand (Wikipedia Lane n.d.).

The last rule matters most where gloves are scarce, and it takes practice: tying knots and passing needles with two pairs of long forceps until it is quick [VERIFY: own suggestion].

1.10 Surgical hand and arm washing

WHO 2003 gives a scrub of at least 5 minutes for the first case of the day and at least 3 minutes for later ones: soap, a brush for nails and fingertips, running water from hands to elbows, hands held up so water runs off at the elbows, and a sterile towel (WHO 2003).

The Cochrane review of 2016 found 14 trials, 4 reporting surgical site infection, all of low or very low quality. Alcohol rubs with additives against aqueous antiseptic scrubs gave a risk ratio of 1.02 (95% CI 0.70 to 1.48) in 4,387 patients (Tanner et al. 2016). That trial was Parienti's, in six French services: a 1-minute plain soap wash and then a 5-minute 75% alcohol rub gave 2.44% infection against 2.48% for a 5-minute povidone-iodine or chlorhexidine scrub, and staff kept to the required time more often with the rub, 44% against 28% (Parienti et al. 2002, via summaries).

The trial closest to post-Fall conditions is Nthumba's at Kijabe in rural Kenya in 2007. Among 3,317 patients, a plain soap and water scrub gave 8.0% infection against 8.3% for alcohol rub, an odds ratio of 1.03 (95% CI 0.80 to 1.33), at a weekly cost of €3.30 against €4.60 (Nthumba et al. 2010). A Basel trial found 1.5-minute and 3-minute rubs equally effective on hand flora (Weber et al. 2009, abstract via search).

A timed, supervised soap and running-water scrub does as well as alcohol rub. Rub helps where water is short, and HY-01 covers the WHO formula and its fire risk (THRIVING library, HY-01). Hard brushing damages skin [VERIFY], so brush the nails with a soft brush or a stick at the first scrub only.

1.11 Gloves and glove substitutes

What gloves add. Holes are common: 41.4% of emergency and 34.3% of elective operations in Addis Ababa (BMC Surgery 2017). In Basel, across 4,147 procedures, a perforated glove doubled the odds of infection. Without antibiotic prophylaxis the adjusted odds ratio was 4.2 (95% CI 1.7 to 10.8), infection 12.7% against 2.9%, and with prophylaxis perforation made no difference (Misteli et al. 2009). Without antibiotics, glove integrity matters more.

For simple lacerations, sterile gloves add little. In 816 emergency-department lacerations, infection was 6.1% with sterile gloves and 4.4% with clean non-sterile gloves, a difference that was not statistically significant (Perelman et al. 2004, via summary).

Reusing gloves. Hesperian uses clean gloves for intact skin, high-level disinfected gloves for broken skin or the vagina and sterile gloves for surgery. It warns that heat sterilising usually melts gloves, asks for reused gloves to be checked for holes, and suggests clean plastic bags when there are none (Hesperian 2023). Reprocessed gloves perforate more often, 54.29% against 38.95% for new ones in one study, and WHO advises against reprocessing without a validated method [VERIFY: search summaries, sources not traced]. Holes are hard to see, so this report suggests filling each glove with water and squeezing [VERIFY].

Substitutes, in order of preference. 1. New sterile gloves, kept for operations into body cavities, joints or bone. 2. Boiled or steamed rubber gloves (high-level disinfected) for deliveries, wound care and minor procedures. Early surgery boiled its gloves [VERIFY: secondary only]. 3. Clean non-sterile gloves for lacerations and dressings (Perelman et al. 2004). 4. No gloves, a careful scrub and the no-touch technique when nothing else exists (Wikipedia Lane n.d.). 5. Clean plastic bags over scrubbed hands to keep blood off the worker (Hesperian 2023).

1.12 Needles and syringes: the hepatitis and HIV lesson

This is where unsafe sterilisation has done its greatest harm. In 2000, contaminated injections caused an estimated 21 million hepatitis B infections, 2 million hepatitis C infections and 260,000 HIV infections, about 32%, 40% and 5% of new infections. People in the regions studied received 3.4 injections a year, and 39.3% were given with reused equipment (Hauri et al. 2004, abstract via search).

Egypt. Mass treatment for schistosomiasis with intravenous tartar emetic, 12 to 16 injections per course from the 1950s to the 1980s, was called the world's largest iatrogenic transmission of blood-borne pathogens and linked to Egypt's very high hepatitis C prevalence (Frank et al. 2000, abstract via search). Later modelling gives the campaign a smaller share [VERIFY: Ayoub et al. 2020, search summary only, about 6%]. The mechanism was glass syringes reused between patients without adequate sterilisation.

Elista. In 1988 and 1989 children in hospital in Elista, Kalmykia, were infected with HIV because staff changed the needle and reused the syringe. The outbreak spread to other hospitals in southern Russia (Wikipedia HIV in Russia n.d., Caucasian Knot 2012). Russian-language sources give 75 children and 4 adults [VERIFY]. Blood flows back into the barrel, so a new needle does not make an old syringe safe.

Roka, Cambodia. Between December 2014 and February 2015, 242 new HIV cases in one commune were traced to injections and infusions by an unlicensed practitioner (CDC MMWR 2018).

Early warnings. In the early 1940s British Army investigators linked jaundice after syphilis treatment to unsterilised syringes, and a 1945 Ministry of Health memorandum warned that traces of blood on syringes could transmit what was almost certainly hepatitis B (Mortimer 1995, abstract via search).

Hepatitis B survives at least 7 days dried on a surface (Bond et al. 1981, abstract) but is not heat-resistant (HBV heat review 2020). The failures were failures to apply heat at all: syringes rinsed, wiped with alcohol or boiled too briefly.

After the Fall, glass and metal syringes will return. One sterile needle and one sterile syringe for each person for each injection. Syringes are taken apart, cleaned and steamed with the plunger out. Where steam fails, boiling for 20 minutes protects against blood-borne viruses but leaves the spore risk.

1.13 Cleaning the room

The CDC and ICAN guidance for resource-limited settings sets four routines for operating rooms (CDC and ICAN 2019).

- **Before the first case:** damp-wipe horizontal surfaces with disinfectant and check that the previous terminal clean was done.
- **Between cases:** clean and disinfect high-touch surfaces, anything visibly soiled and everything in the surgical field, including the floor around the table. Remove linen, waste and kick buckets.
- **At the end of the day (terminal clean):** clean everything, moving the table and cleaning the scrub sinks.
- **Weekly:** low-touch surfaces such as walls, shelves and vents.

Mops are reprocessed immediately after a spill. HY-05 gives 0.2% chlorine for floors and 0.5% for blood spills (THRIVING library, HY-05). WHO 2016 gives a stronger 1% for spills. Both agree on wiping up the bulk first.

1.14 Infection rates by method

The evidence for the effect of each step on outcomes is thin and confounded.

Comparison	Outcome	Source
Bloodgood, hernia repairs without and with gloves	Infection over 17% against under 2%, confounded	Secondary, [VERIFY]
Parienti, alcohol rub against antiseptic scrub	2.44% against 2.48%	Parienti et al. 2002
Nthumba, plain soap against alcohol rub, Kenya	8.0% against 8.3%	Nthumba et al. 2010
Misteli, perforated against intact gloves, no prophylaxis	12.7% against 2.9%	Misteli et al. 2009
Perelman, sterile against clean gloves for lacerations	6.1% against 4.4%, not significant	Perelman et al. 2004
Developing countries, pooled surgical site infection	5.6 per 100 procedures	Allegranzi et al. 2011, abstract via search, [VERIFY]

No study was found that compares infection rates after instruments boiled against instruments steamed in human surgery. The outbreak literature shows the harm of failure in the other direction. A review of 21 reports of sterilisation and reprocessing failures found 6 exposure incidents, involving 1 to 250 patients, and 15 outbreaks of 6 to 302 cases, some fatal, with organisms such as Proteus mirabilis, Mycobacterium chelonae and Pseudomonas aeruginosa (Chanchareonsook et al. 2022, citing Southworth 2014).

2. Evidence grades

A: strong (controlled studies or settled physics). B: moderate (good observational or laboratory data, consistent guidelines). C: weak (case series, expert opinion). D: very weak (anecdote). X: contradicted by the record.

Claim	Tradition says	Record shows	Modern science infers	Grade
Steam at 121 °C for 15 to 30 min sterilises a clean load if air is removed	Autoclave is the gold standard	Universal in guidelines	Spore D-values support it	A
A stovetop 15 psi pressure cooker can sterilise	Field manuals say yes	One indicator study, all 128 passed	Physics agrees at sea level	B
Electric multicookers sterilise	Sold as “pressure cookers”	Three of four failed at 300 min	They do not reach 121 °C	X
Boiling 20 min sterilises	Widely believed	WHO calls it unacceptable for sterilisation	Spores survive	X
Boiling 20 min gives high-level disinfection	Hesperian, WHO teaching	Consistent	Kills HBV, HIV, vegetative bacteria	B
Dry heat at 170 °C for 1 to 2 h sterilises	CDC, WHO	Consistent, with time disagreements	Ovens vary, load lag	B
70% alcohol sterilises instruments	Common practice	Clostridium deaths after alcohol	Not sporicidal, fixes soil	X

Claim	Tradition says	Record shows	Modern science infers	Grade
Flaming sterilises instruments	Folk practice	No source found	Surface heating is brief and uneven	D
Carbolic made surgery safer	Lister tradition	Small numbers, epidemic cycles, Tait's water	Asepsis, not antisepsis, carried the gain	C
Plain soap scrub equals alcohol rub	Old practice	Kenyan RCT, 3,317 patients	Mechanical removal does the work	B
Gloves reduce surgical infection	Accepted	Perforation raises risk, most without antibiotics	Barrier works when intact	B
Clean gloves are enough for lacerations	Contested	One RCT, 816 patients	Plausible	B
Reused syringes spread HBV, HCV, HIV	Known since 1940s	Egypt, Elista, Roka	Proven mechanism	A
Pre-soak instruments in chlorine before cleaning	WHO 2003	WHO 2016 reverses it	Corrosion, inactivation	C
Sterile packs keep 4 weeks if dry and intact	ICRC rule	Thai data suggest 60 days	Event-related	B
No-touch technique protects without gloves	Lane's practice	No trial found	Plausible	C

3. Means ledger

Rung	What they have	Instruments	Dressings	Hands	Highest reliable rung
Hands	Water, fire, soap if any	Scrub, boil 20 min in any pot, use while hot	Boiled cloth, dried in sun, ironed	Soap and running water, no-touch technique	High-level disinfection
Hearth	Lidded pots, oven, salvaged pressure cooker	Clean, then pressure cooker 15 psi 20 to 30 min, or bake	Steam in cooker, dry in the closed cooker	Timed scrub, boiled rubber gloves if any	Sterile at sea level with a working 15 psi cooker
Garden and still	Distillation, alcohol, ash lye, soap, some bleach	As hearth, alcohol for skin and clean surfaces	As hearth	As hearth, alcohol rub (HY-01 formula)	Sterile, if a cooker exists

Rung	What they have	Instruments	Dressings	Hands	Highest reliable rung
Village dispensary (300 people)	One or two cookers, store, log book, a trained keeper	Cooker cycles logged, packs dated	Double cotton wraps, closed boxes	Supervised scrub, glove rationing	Sterile, logged
District infirmary (3,000 people)	Salvaged autoclave, fuel, indicator stocks, laundry	Autoclave 121 or 134 °C, TST strips, Bowie-Dick if vacuum type	Drums or packs, 4-week rule	Scrub room, sterile gloves for major operations	Sterile, verified
Hospital before the Fall	Pre-vacuum autoclaves, washer-disinfectors, low-temperature sterilisers	Validated cycles, biological indicators	Validated packs	Alcohol rub, sterile gloves	Sterile, validated

The main costs are fuel and time. A 39-litre cooker needs at least 1,500 W or a strong burner (ICRC 2014), and a full run with venting, holding, cooling and drying takes about 90 minutes [VERIFY: own estimate].

4. Harm test

Each method can hurt someone. The question is whether the harm is smaller than the harm prevented.

Pressure cookers. Scalds and explosion. A case series of domestic pressure-cooker burns appeared in the Ceylon Medical Journal (Ceylon Med J 2012, abstract only). Search summaries report a series of 32 cases with 87% second-degree burns, mostly face and arms, but this report could not tie those figures to that paper [VERIFY]. The causes are opening under pressure, blocked vents and boiling dry. ICRC adds: never pour cold water on a warm autoclave, check the exhaust tube monthly, and wait 5 minutes after opening before handling the load (ICRC 2014). A maintained cooker passes the test.

Boiling and dry heat. Scalds, burns, scorched cloth and softened steel. Ovens run 30 to 40 °C off (JSOM 2016). The larger harm of boiling is treating it as sterilisation.

Alcohol. Fire (THRIVING library, HY-01), fixed soil on instruments, and Clostridium infection after alcohol "disinfection" (Rutala et al. 2008).

Chlorine. Chlorine gas with acids or ammonia, burns at high strength, corroded steel (Rutala et al. 2008, WHO 2016). WHO 2003 says to neutralise acid with sodium bicarbonate before bleach goes into drains or laundry.

Carbolic (phenol). History: Lister's antiseptic, now obsolete. Benefit: kills vegetative bacteria, not spores. Harm: absorbed through skin and wounds, toxic to kidneys and nervous system. Dose: minimal lethal oral dose near 70 mg/kg, as little as 1 g may kill, and deaths have followed skin contact over more than a quarter of the body (ATSDR 2008, search summary). Signs of poisoning: dark or smoky urine, scanty urine, white painless skin burns, collapse, convulsions and coma within minutes to hours, with children most at risk (Carbolic poisoning article n.d., ATSDR 2008). Feasibility: coal-tar phenol needs industrial chemistry. It should not be revived when steam and soap do better.

Formaldehyde and glutaral. WHO 2003 lists formaldehyde vapour and glutaral as fallbacks when the autoclave

fails. Both injure skin, eyes and lungs, and formaldehyde is a carcinogen [VERIFY: not from a source read here]. Neither is recommended for village use, and no preparation is given.

Gloves. Latex allergy, and reprocessed gloves with unseen holes giving false protection.

The worst harm is false sterility. An electric multicooker that never reaches 121 °C, a cooker that lost pressure halfway, an unwrapped instrument handled after the lid came off, a wet pack: each looks sterile and is not. The checks in the protocols exist to catch these.

5. Red flags

Stop and repeat the cycle, or treat the item as unsterile, if any of these happens.

- The cooker stopped hissing or rocking during the hold time.
- The water ran dry or the base glowed.
- A pack is damp, stained, torn, dropped or opened.
- The indicator did not change, or changed only partly.
- Instruments still show blood or tissue after cleaning.
- The cooker is electric, or its pressure is unknown or under 15 psi.
- Altitude above 1,000 m and no time correction was made.
- A syringe or needle has been used on anyone else.
- A glove has a hole, or a gloved hand touched anything outside the field.
- A wound after surgery shows spreading redness, crackling under the skin, foul grey discharge or stiff jaw muscles. These suggest gas gangrene or tetanus and need the help described in WO-14 [VERIFY: WO-14 not yet in the library when read].

6. The case against

Against the ladder. Tait's results improved as he gave up carbolic for water, and 1860s hospital mortality rose and fell with epidemics whatever the method (Tröhler 2014). A sceptic can argue that cleanliness, not sterility, did most of the work, and that a village obsessed with sterility will burn scarce fuel on cooker cycles for wounds that would heal anyway. Soap equalled alcohol rub for hands (Nthumba et al. 2010), and clean gloves equalled sterile ones for lacerations (Perelman et al. 2004).

Against the pressure cooker and boiling. The direct evidence is one indicator study of 128 runs with one brand, published as a short military-journal paper, and one negative study of electric cookers (Cook et al. 2021, Swenson et al. 2018). No study tied cooker sterilisation to patient outcomes. Salvaged cookers will have worn seals and unknown weights, WHO 2016 discourages pot-style sterilisers outside primary care, and it calls boiling unacceptable for sterilisation.

Response. The physics of steam is not in doubt, and Cook's cooker is the UNICEF pot steriliser in a smaller size. The real risk is lapsed discipline, which the protocols meet with logs, indicators and red flags. Boiling stays right for semi-critical items and emergencies, if it is called high-level disinfection and not sterilisation.

7. 10-line summary

1. Clean first, always. Nothing can be sterilised through dirt.
2. Boiling for 20 minutes from a full boil kills blood-borne viruses and vegetative bacteria but not all spores. It is high-level disinfection.
3. Steam at 121 °C (15 psi at sea level) sterilises: 20 minutes for unwrapped metal, 30 minutes for anything wrapped or folded.
4. A stovetop pressure cooker with a 15 psi weight can work. Electric multicookers do not.

5. Remove air by venting steam before closing, and restart the clock if pressure is lost.
6. Above 1,000 m a cooker runs cooler, so lengthen the hold time and use indicators.
7. Dry heat needs 170 °C for 1 to 2 hours, measured in the load. Ovens lie.
8. Alcohol and flame do not sterilise instruments. Alcohol is for clean skin.
9. A timed soap and running-water scrub equals alcohol rub. Gloves help most when antibiotics are scarce.
10. One needle and one syringe per person per injection, each sterilised. Changing the needle is not enough.

8. Open questions

- What temperature does a salvaged domestic cooker reach at village altitude? No source measured it.
- Is there an improvised indicator that changes at 121 °C and not below? None was found.
- How well do boiled rubber gloves hold up over repeated cycles, and how many holes do they have after 5, 10 and 20 boilings?
- What is the infection rate in human surgery when instruments are boiled rather than steamed? No comparative study was found.
- What are the measured D-values of soil Clostridium spores at 100 °C? Pathogen-specific spore data could not be obtained.
- How does King's Primary Surgery handle sterilisation? It could not be read.
- What does MSF currently recommend for pressure-cooker sterilisation? The MSF guideline was not found.
- How long can sterile cotton packs be stored in a humid tropical village house rather than a controlled store?

9. Sources to read in full

1. WHO 2016, Decontamination and Reprocessing of Medical Devices. The best modern manual. Read in full here.
2. ICRC 2014, Sterilization Guidelines, with the annex on the UNICEF pressure-cooker autoclave. Read in full here.
3. Rutala, Weber and HICPAC 2008, the CDC guideline, sections on steam, dry heat and chemical disinfectants.
4. Hesperian 2023, Where Women Have No Doctor, pages 527 to 529, for lay teaching.
5. WHO 2003, Surgical Care at the District Hospital, for the older view and the fallbacks.
6. Cook et al. 2021 and Swenson et al. 2018, the only direct tests of pressure cookers found.
7. Nthumba et al. 2010, soap scrubbing in a rural hospital.
8. Tröhler 2014, on Lister's statistics.
9. Schimmelbusch's 1894 English handbook of aseptic treatment, not read [VERIFY availability].
10. King, Primary Surgery, volume 1, not read, for district sterilisation without electricity.

10. At the bedside after the Fall

In the record, methods failed when people stopped doing them properly, not when the heat failed (Dicko et al. 2000). So a village names one keeper of the steriliser, who cleans, packs, runs the cooker, dries the packs, writes the log and guards the store. Nobody else opens the store.

At the bedside, the first question is what the procedure needs. Stitching a clean cut or a delivery can be done with boiled instruments, boiled or clean gloves and a soap scrub. A deep soil-contaminated wound, an amputation, or an operation into a joint or the abdomen needs instruments and dressings from the cooker, the best gloves kept back for it, and the no-touch technique.

Before an operation the keeper checks the pack date, the dry wrap and the indicator, and sends back any pack that fails. The operator scrubs for 5 minutes under water poured by a helper from a clean jug if there is no tap. The helper opens the outer wrap and the operator takes the inner pack. One person watches the field. Dropped instruments go to the dirty basin.

Afterwards, instruments are rinsed cold before blood dries, scrubbed open at the hinges, rinsed and dried, never wiped with alcohol. Sharps go into a closed container. The keeper counts syringes and needles out and back.

When the cooker fails, the work goes on. Boil the instruments for 20 minutes, lift them out with boiled forceps, scrub carefully, use the no-touch technique, and record that the case used disinfected rather than sterile instruments, so the patient is watched for tetanus and gas gangrene (WO-14 when written).

11. Protocols

Protocol 1. Cleaning instruments before any heat

Sources: WHO 2016, Hesperian 2023.

- ☐ Wear heavy gloves if any are available. Keep instruments moist after use, in a closed container.
- ☐ Rinse in cool water (below 60 °C) as soon as possible. Hot water fixes protein.
- ☐ Open all hinges and take apart anything that comes apart (syringe plungers out, needles off).
- ☐ Scrub every surface under water with soap or detergent and a soft brush.
- ☐ Flush any lumen with soapy water at least 3 times [VERIFY: own suggestion].
- ☐ Rinse, inspect in good light, repeat if soil remains, dry.
- ☐ Do not soak in chlorine or wipe with alcohol before cleaning (WHO 2016). Exception: sharps that must be handled with bare hands may be soaked in 0.5% chlorine for 10 minutes, then rinsed at once [VERIFY: inference].

Protocol 2. Boiling for high-level disinfection

Sources: Hesperian 2023, Conant and Fadem 2008, Doh 2007.

- ☐ Clean the items first (Protocol 1).
- ☐ Cover the items with water by at least 2.5 cm in a lidded pot [VERIFY: depth not stated in sources read]. Bring to a full rolling boil, lid on.
- ☐ Start timing at the full boil. Hold 20 minutes. Tolerance: none downwards.
- ☐ Add nothing after timing starts. If anything is added, restart at zero.
- ☐ At altitude, add 5 minutes per 1,000 m [VERIFY: own suggestion, no source found].
- ☐ Lift items with boiled forceps onto a boiled cloth or into a boiled, covered container. Use the same day.
- ☐ Log date, items, times and name. Label the result high-level disinfected, not sterile.

Protocol 3. Sterilising with a stovetop pressure cooker

Sources: ICRC 2014, Rutala et al. 2008, WHO 2003, WHO 2016, Hesperian 2023, Cook et al. 2021. Two or more sources for each time.

Before first use: - [ ] Confirm it is a stovetop cooker with a 15 psi (about 1 bar) weight or gauge. Electric multicookers fail (Swenson et al. 2018). - [ ] Check the seal is soft and whole, the vent is clear, the safety plug is present. - [ ] Note the altitude.

Each run: - [ ] Clean and dry the items (Protocol 1). - [ ] Wrap packs in two layers of cotton cloth or crepe paper, loosely, with an indicator strip inside if available and tape outside. - [ ] Put water in the base, below the rack. ICRC's 39-litre unit takes 3 litres. Scale down for small cookers [VERIFY: about 2 to 3 cm, own estimate]. Use rain or boiled water (WHO 2016 asks for distilled). - [ ] Load on the rack, above the water, fill no more than three quarters, with space between packs. Lay a clean towel over the load. - [ ] Do not mix linen and instruments in one load (ICRC 2014). - [ ] Close the lid with the vent open. Heat at full power. - [ ] Let steam vent in a steady jet for 10 minutes to drive out air [VERIFY: home-canning practice, not read], or follow the ICRC purge cycles if the cooker has a gauge and a purge valve. - [ ] Put the weight on or close the valve. Wait until full pressure. - [ ] Start timing at full pressure.

Hold: - 20 minutes for unwrapped metal instruments (WHO 2003, Hesperian 2023, Cook et al. 2021). - 30 minutes for wrapped packs, cloth, dressings and syringes (Rutala et al. 2008, WHO 2003). - Above 1,000 m, double the time [VERIFY: own calculation]. - [ ] Keep heat steady. The weight must rock or hiss throughout. If it stops, restart timing at zero once pressure returns [VERIFY]. - [ ] Turn off the heat. Let pressure fall by itself to zero. Never cool with water. - [ ] Open the lid a crack. Leave the load to dry in the cooker for at least 30 minutes (ICRC 2014). - [ ] Remove packs only when dry and cool. Discard any damp, stained or torn pack (WHO 2016). - [ ] Check indicators. Log the run: date, load, time to pressure, hold time, indicator result, name.

Maintenance: - [ ] Clean the vent before each run. - [ ] Descale with vinegar diluted about 1 to 16 in water when scale builds up (JSOM 2016 gives 1 quart of vinegar to 4 gallons of water). - [ ] Replace the seal when it hardens or cracks [VERIFY: no interval found].

Protocol 4. Dry heat in an oven

Sources: Rutala et al. 2008, WHO 2003, JSOM 2016, Hesperian 2023.

- ☐ Metal and glass only. No rubber, plastic or cloth beyond the wrap.
- ☐ Clean and dry the items (Protocol 1).
- ☐ Wrap in up to four layers of paper or cloth, or use a metal box with a loose lid.
- ☐ Single layer in the oven, space for air (JSOM 2016).
- ☐ Heat to 170 °C. Check with an oven thermometer if possible. Expect an error of up to 30 to 40 °C in an unchecked oven.
- ☐ Start timing when the load, not the oven, reaches temperature. Allow at least 30 minutes for this [VERIFY: own estimate].
- ☐ Hold 170 °C for 2 hours (WHO in JSOM 2016, WHO 2003 gives 1 to 2). If the oven is uncertain, use 2.5 hours (Hesperian 2023).
- ☐ Cool in the closed oven. Store closed.

Protocol 5. Chlorine solutions for surfaces and spills

Sources: THRIVING library HY-05, Rutala et al. 2008, WHO 2016.

- ☐ Use the dilution rule: parts of water per part bleach = (bleach % ÷ % wanted) minus 1.
- ☐ From 5% bleach: 0.5% is 1 part bleach to 9 parts water. 0.2% is 1 to 24. 0.05% is 1 to 99 (THRIVING library, HY-05).
- ☐ Assume salvaged bleach is half its label strength unless tested.
- ☐ Make fresh daily, in plastic, never mixed with acid or ammonia.
- ☐ Blood spills: wipe up the bulk with cloth, then flood with 0.5% for 10 minutes, then wipe (HY-05). WHO 2016 uses 1% for spills.
- ☐ Floors and surfaces: 0.2% for 15 minutes.
- ☐ Never use chlorine as the sterilising step for instruments.

Protocol 6. Surgical hand and arm scrub

Sources: WHO 2003, Nthumba et al. 2010, Parienti et al. 2002.

- ☐ Nails short, no rings. Running water from a tap or a jug poured by a helper.
- ☐ First scrub of the day: 5 minutes. Later scrubs: 3 minutes. Time it.
- ☐ Clean under nails with a stick or soft brush at the first scrub.
- ☐ Wash each finger, between fingers, both sides of the hand, then the forearm to the elbow, hands held above the elbows.
- ☐ Dry with a sterile towel, hand first, then forearm, never back.

☐ If alcohol rub is used instead: wash with plain soap first at the first case, then rub until dry for at least 1.5 to 3 minutes (Weber et al. 2009, Parienti et al. 2002). Keep away from flame.

Protocol 7. Gloves and glove substitutes

Sources: Hesperian 2023, Misteli et al. 2009, Perelman et al. 2004.

☐ Sterile new gloves: for open body cavities, bone, joints and amputations.
☐ Boiled rubber gloves (20 minutes): for deliveries and minor procedures. Dry, powder if available, store in boiled cloth [VERIFY: powder use].
☐ Clean non-sterile gloves: for stitching cuts and changing dressings.
☐ Before reuse, fill each glove with water and squeeze to find holes. Discard any that leak.
☐ Change a glove at once if it tears or touches anything outside the field (WHO 2003).
☐ No gloves: scrub, then no-touch technique only.

Protocol 8. Setting up a sterile field

Sources: WHO 2003, WHO 2016, Wikipedia Lane n.d., with [VERIFY] items from general practice.

☐ Clean the table with 0.2% chlorine or soap and water. Let it dry.
☐ Check pack date, dryness, wrap and indicator.
☐ Open the outer wrap away from you first, then sides, then towards you [VERIFY].
☐ Only the gowned or scrubbed person touches the inside.
☐ Only the top of the table is sterile [VERIFY].
☐ Keep instruments on the field, not in hands, between uses.
☐ Use long forceps for anything that enters the wound when gloves are absent or poor.
☐ Name a watcher. Anything in doubt is unsterile.

Protocol 9. Syringes and needles

Sources: Hauri et al. 2004, Mortimer 1995, Rutala et al. 2008, HBV heat review 2020.

☐ One sterile needle and one sterile syringe per person per injection. No exceptions.
☐ After use, flush syringe and needle with cold water at once, then take the syringe apart.
☐ Clean (Protocol 1). Flush needles with soapy water and then clean water.
☐ Steam-sterilise in the cooker, plungers out, 30 minutes (Protocol 3). Store each set wrapped.
☐ If steam is not available: boil for 20 minutes (Protocol 2), use the same day, and note that the spore risk remains.
☐ Check each needle tip for burrs and blunting. Discard bent or burred needles [VERIFY: sharpening is outside this report].
☐ Never “disinfect” a syringe with alcohol or by changing the needle only.

Protocol 10. Storage of sterile packs

Sources: WHO 2016, ICRC 2014, Apinhapath and Jongpremkijpaisan n.d.

☐ Cool packs fully on a rack before storing.
☐ Store in a closed box (wood or plastic) off the floor, away from water, sun and smoke.
☐ Write the date on each pack. Use the oldest first.
☐ Keep for 4 weeks if dry and intact. Re-sterilise after that.
☐ Discard as unsterile any pack that is wet, torn, dropped or opened.
☐ Check the store weekly.

Protocol 11. Cleaning the room

Source: CDC and ICAN 2019, HY-05.

- ☐ Before the first case: damp-wipe horizontal surfaces and the table with 0.2% chlorine.
- ☐ Between cases: wipe everything touched and all soil. Clean the floor around the table. Remove waste and linen.
- ☐ Spills: wipe the bulk, then 0.5% chlorine for 10 minutes.
- ☐ End of day: clean everything, moving the table. Clean the wash basin.
- ☐ Weekly: walls, shelves and less-touched surfaces.
- ☐ Wash mops and cloths after each spill and dry them in the sun.

12. Numbers to carry

- Boil: 20 minutes from the full boil. High-level disinfection only.
- Steam: 121 °C, 15 psi at sea level. 20 minutes unwrapped, 30 minutes wrapped.
- Hospital steam: 134 °C, 2.1 bar, 18 minutes.
- Vent steam before closing. Restart the clock if pressure is lost.
- Altitude: cooker loses about 2 °C per 1,000 m [VERIFY]. Double the time above 1,000 m.
- Dry heat: 170 °C for 1 to 2 hours, 160 °C for 2 hours, 150 °C for 2.5 hours, timed in the load.
- Alcohol: 60% to 90%. Clean skin only. Kills no spores.
- Chlorine: 0.05% hands and laundry, 0.2% floors, 0.5% blood spills (10 minutes).
- Scrub: 5 minutes first, 3 minutes later.
- Sterile pack life: 4 weeks if dry, intact and closed.
- Gloves: a hole doubles infection risk, and quadruples it without antibiotics.
- Injections: one needle, one syringe, one person, one time.
- Carbolic: as little as 1 g swallowed can kill. Do not revive it.

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