Sterile Science

Reprocessing of surgical instruments is a collective task!

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"They just need to buy some extra washing machines!"

"I don't have enough time to do THEIR work as well!"

These statements were voiced at a morning meeting for surgical nurses, where I was invited to present our sterile science research focusing on the reprocessing of surgical instruments. Unfortunately, these statements are neither unique nor one-sided, as I have heard staff from the Central Sterile Supply Department (CSSD) wonder why instruments are not groomed properly when they are returned from the operating room (OR).

This paper discusses sterile science and why knowledge of reprocessing surgical instruments is equally important for the surgical team as it is for the CSSD staff. Furthermore, the paper underlines how each individual staff members contribution is pivotal for securing both patient safety and value preservation of instruments.

What do we know?

Sterile Science concerns proper handling of surgical equipment the field of reprocessing. Reprocessing of surgical equipment is a neglected research area. National and international recommendations are based on relevant requirements laid down in regulations, standards, subject-specific knowledge in relevant areas such as hygiene and metallurgy, and to a large extent consensus on "best practice". However, evidence-based knowledge to support these recommendations is limited.[1-3]

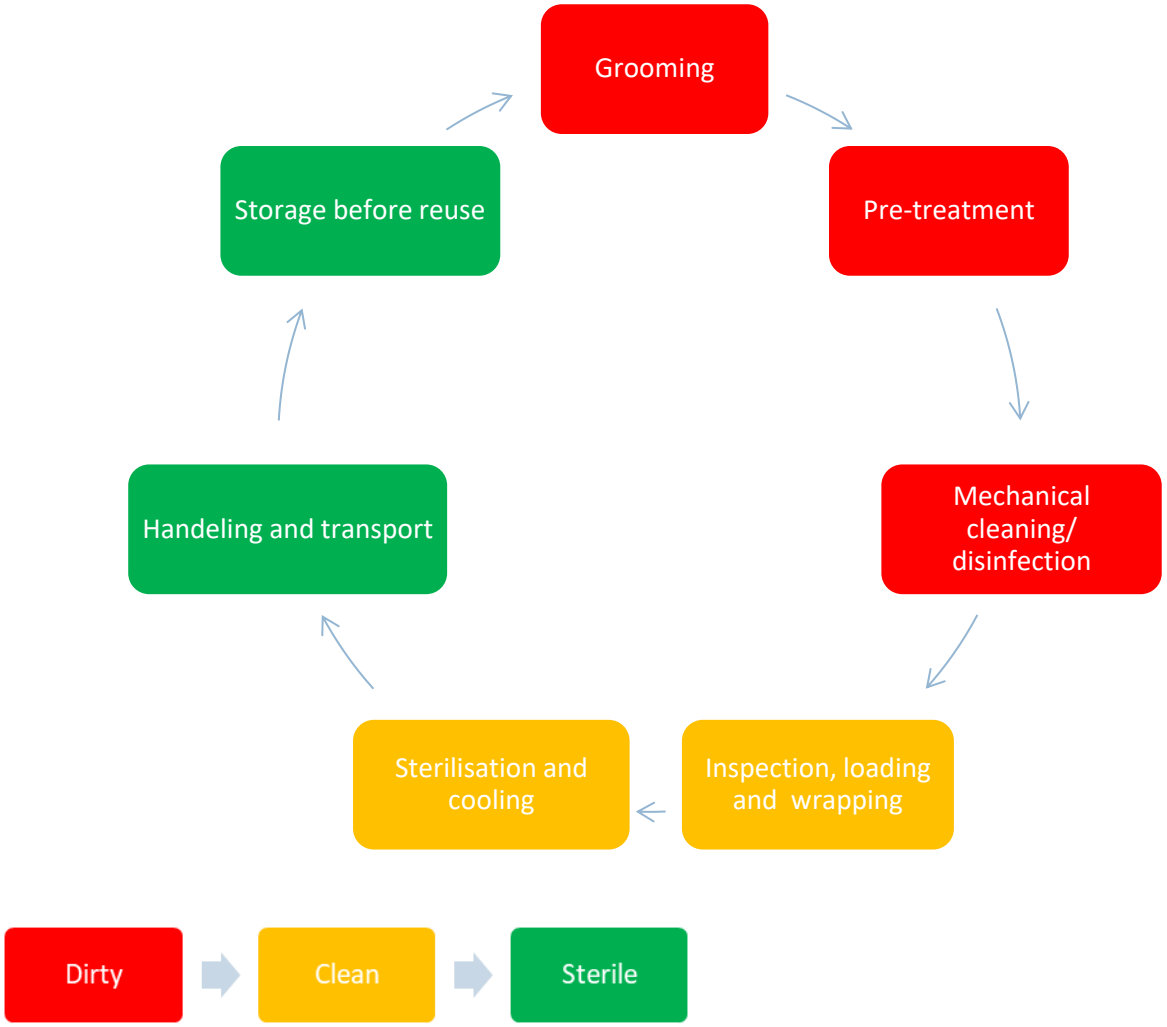
Over the past few years, the limited existing research has focused on identifying which environment instruments should be stored in between the OR and the CSSD to get the best possible cleaning result.[4-6]

Standards for the automated washing, disinfection, and sterilization processes, continuously undergoes quality monitoring, and the processes have been improved in line with the technological development, e.g., with higher requirements for the degree of cleanliness (e.g., A0 values which is a physical parameter denoting the inactivation of microorganisms).[7] Even though there are well-described recommendations for grooming at the OR, focus on this area has been limited.

Why do we reprocess surgical instruments?

The goal of reprocessing sterilizable surgical instruments is to avoid transmission of infection in connection with the use of reusable instruments as well as to maximize the number of times these instruments can be reused. A prerequisite for securing that the reprocessing process leads to a sterile product depends on proper handling of the instruments at all stages. The reprocessing process starts with grooming at the OR, continues at the CSSD with manual cleaning, mechanical cleaning / disinfection, inspection, wrapping, sterilization, and handling instruments in transit between CSSD and OR.[1-3]

Illustration of the reprocessing process



The main purpose of grooming surgical instruments at the OR is to remove any debris, blood, or tissue remnants that may be present on the instruments after use. The following thorough cleaning of instruments at the CSSD helps prevent the transmission of infections and reduces the risk of post-operative complications. Properly reprocessed instruments not only ensure the success of surgical procedures but

also contribute to the overall patient safety. The importance of proper reprocessing of surgical instruments extends beyond patient safety and will result in saving resources; man-power, water, detergents, and energy for repeated washing, disinfection, and sterilization; and metal and other materials for the manufacturing of new instruments. Regular inspection and maintenance of instruments will ensure their proper functioning, preventing any potential malfunctions during surgeries. Hence, well-maintained instruments contribute to the efficiency and effectiveness of surgical procedures as it enables surgeons to perform their tasks with precision and accuracy, reducing the risk of errors and complications. This, in turn, leads to improved surgical outcomes and shorter operative times.[1-3]

The effectiveness of OR's are multi-factorial, and research shows how scheduling and planning quality, the individual surgeons' efficiency, the team cooperation and communication, and the patients' general health condition are all factors that impact OR efficiency.[7-9] Effective communication and collaboration between the OR and CSSD staff are crucial aspects of maintaining a safe and efficient surgical environment as these support identifying issues or concerns related to instrument quality or availability, allowing for timely resolution, and uninterrupted surgical procedures.[9-11]

How to ensure that surgical instruments are sterile and preserve their quality for as long as possible, to secure patient safety and save resources, is therefore highly relevant for both clinicians, managers, economists and experts within hospital hygiene, climate, and sustainability.

The corrosion triangle of surgical instruments

The development of corrosion on surgical instruments can be compared to the development of a fire in terms of the fire triangle concept. The fire triangle consists of three elements necessary for a fire to occur: fuel, heat, and oxygen. Similarly, the development of corrosion on surgical instruments involves three factors: metal, soiling, and drying.

1. Metal (Fuel): In the case of corrosion, the metal in surgical instruments acts as the fuel. Surgical instruments are typically made of martensitic stainless steel and consist of iron, carbon, chromium, nickel, and other metals in smaller amounts. The steel's corrosion resistance, mechanical strength, formability etc. depend on the quantity and composition of these components. Especially the Chromium content up to 16% determines the instruments corrosion resistance.[12]

Stainless steel is not as the name indicates corrosion free as all surgical instruments will corrode over time. Hence prolonged exposure to blood, and other corrosive substances, will lead to the breakdown of the protective layer on the metal surface, making it more susceptible to corrosion.

2. Soiling (Oxygen): During surgery instruments are in contact with various bodily fluids, saline containing Sodium Chloride, and other corrosive substances. If cleaning is ineffective and these fluids remain on the

instrument surface, they can access the metal surface through microscopic imperfections or damaged protective coatings. Furthermore, when insufficient cleaned instruments are exposed to high temperatures associated with washing, disinfection and sterilization, the bio-contamination can, over time solidify in an insoluble biofilm that acts as a physical barrier that compromises the sterilization process and thereby threaten patient safety.[13-14]

3. Drying (Heat): Drying plays a role similar to heat in the fire triangle. When liquids evaporate salt residues from the bodily fluids, saline and other corrosive substances remain on the surface. Halogen salts and especially Chlorides is the primary leading cause to the formation of corrosion products on the instruments. Research demonstrates that drying of bio-contamination on instruments significantly increase the risk of corrosion and thereby compromising the quality of the instrument.[6,15,16]

What separates the corrosion triangle from the fire triangle is that it is impossible to completely remove one of the elements. We need the surgical instrument to perform the surgery, the instrument will be contaminated with bodily fluids and saline, and there will always be a risk of liquid evaporating from the instrument surface during transportation between the OR and CSSD before reprocessing is initiated. However, to prevent the development of corrosion on surgical instruments, it is important to address each element of the corrosion triangle. This includes using high-quality stainless-steel instruments that have good corrosion resistance properties (Chromium content 12,5% – 16%) and ensuring fast and thorough cleaning of instruments after they are used. Understanding and addressing these factors are crucial in preventing corrosion and maintaining the integrity and functionality of surgical instruments.[15,16] We do not know if residual corrosion on the instrument surface after reprocessing is transferred to the patient during surgery. Neither do we know whether or how much corrosion it takes to pose a risk for the patients' health. Recent research showed a possible causality between the occurrence of corrosion on operatively removed bone lengthening nails and adverse events in patients with pain, osteolysis and periosteal reactions.[17,18] These findings suggest that reducing the incidence of corrosion on reusable surgical instruments will result in patients getting less subjected to corrosion residues during surgeries and any negative effect this may have on their health.

Task prioritizing

Today's healthcare system is under pressure, and in the OR setting this translates in to demands for shorter changeover times between operations to increase number of surgeries per day, better utilization of resources, and a decreased amount of waste. This results in OR staff gets forced to prioritize their tasks, especially during larger operations where many surgical instruments are required. I have no doubts that all OR staff intend to treat the surgical instruments in the best possible way, but because they are under time

pressure, or do not fully understand the essential importance of their grooming for the overall cleaning result, it often becomes ”non-patient-related” tasks that are deprioritized. The time-limited change-over times of e.g., 15 minutes unfortunately does not leave the OR staff much time to take care of the surgical instruments. Instead, they use their sparse time on getting the patient cleaned up and bandaged after surgery ready to leave the OR room, having the OR room cleaned, setting up instruments and preparing the patient for the next surgery. Research underlines the importance of having a clear recommendation for the process of precleaning and for the transport of surgical instruments between OR and CSSD. [19] Staff compliance to such recommendations could improve patient safety by mitigating the risk of surgical site infection and increasing value preservation of the instruments.

Why not just perform the task of grooming instruments somewhere else than in the OR room and by someone else than the OR nurses? Often this is not an option, as hospitals are not equipped with an extra room for cleaning. Furthermore, who should handle the task of collecting the dirty instruments from the OR and groom them before sending the instruments to CSSD? Should it be the OR nurse who is unpacking instruments and setting them up for the next operation, the nurse who is primary responsible for the next patient, or should it perhaps be the porter who also has the task of driving food carts, and carts of dirty instruments from the OR to the CSSD?

Concluding remarks - It requires strong and clear management

Even though all clinicians have a desire to do their job well it is not always possible to do one's work well if the framework and working conditions are not suitable. If clinicians are forced to deprioritize tasks such as grooming in the OR, then it is important that our hospital management both supports the clinicians and agrees on the priorities they must make. At the same time, it requires hospital management to have a clear understanding of the consequences these priorities will have. In Denmark we have very high-quality processes in relation to reprocessing of surgical instruments, so fortunately the risk of casualties is very low. Hence, transmission of infection from one patient to another is primarily a risk if direct errors occur in the reprocessing process such as un-reprocessed instruments are used for more patients.

However, more importantly is the value preservation of our instruments. If instruments are left repeatedly and for many hours with blood, tissue, and saline before they are cared for, their quality will certainly be compromised, and they will be destroyed. The direct consequence is that resources must be allocated away from the patients and instead be used for man-power, water, detergents, and energy for repeated washing, disinfection, and sterilization for the reprocessing of ingrained soil, and if the instruments get destroyed for the production and purchase of new instruments.

The hospital management is therefore faced with a daunting task. They must prioritize where they want to use the healthcare system's scarce resources. The question is, put on a point, whether the financial gain from an increasing surgery activity can cover the costs of having to replace the surgical instruments every three years!!!

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