

Blood Coagulation: Vital for Human Beings – Difficult to Clean

Summary

Blood is doubtless the most frequent contaminant of surgical instruments. In order to exclude any cross-contamination risk for patients and/or personnel maximum cleaning efficiency shall be achieved when reprocessing medical devices. However it is not always easy because of the capabilities of blood to produce water insoluble fibrin fibres. To obtain the best results it is important to match the performance characteristics of all relevant mechanical and chemical parameters of the washer-disinfector and the cleaning detergents.

Key words: Blood; Cleaning; Cleaning Efficiency; Cleaning detergents; Coagulation; Fibrin; Reprocessing; Washer-disinfector

Introduction

All cells in a human being are supplied with oxygen and nutritive substances through the vessel system. More or less all type of surgeries result in a damage of this vessel system and a contact with the transport medium blood. Another important feature of blood is its capability to repair injuries of the system by sealing the damaged vessel. Blood coagulation is vital for the patient but may cause severe problems in the reprocessing of medical devices.

Composition of blood

Proteins play a dominant role in the chemical composition of blood. Other chemical compounds like sodium chloride, glucose or lipids are available at only low levels. Erythrocytes which consist primarily of the protein haemoglobin represent with around 44% the major portion. The erythrocytes are distributed in the blood plasma, which is a 6-8% protein containing hydrous solution. These proteins are of very complex nature and they include also those being responsible for blood coagulation.

Blood coagulation

Theoretically minor injuries could already cause death without the blood immediate capabilities of self-repair through coagulation. Coagulation results in a solidification of liquid blood at the surface of the injured blood vessel. The name of the responsible protein is fibrinogen which is also known as coagulation factor I. During the process of coagulation dissolved fibrinogen converts to insoluble fibrin fibres which then seal the damaged vessel. This requires the system that must be able to identify and locate an injury to produce the vital fibrin right at the spot. The process is initiated by the damage itself which gives the signal for a cascade of enzyme reactions which takes place within a few seconds. This cascade of enzyme reactions guaranties the production of sufficient fibrin even when minor injuries happen.

Blood coagulation will also be initiated whenever blood reaches any non physiologic surfaces. This so called intrinsic coagulation however takes much longer than the emergency reaction after damage (extrinsic coagulation). This explains why fresh blood can only be stored for a few minutes without the addition of anti-coagulants.

Even chemically inert materials such as Teflon or precious metals will initiate this fibrin production of blood. Only the inner surfaces of our blood vessel system are capable to hinder the coagulation process. From an evolution point of view there is still no explanation for the intrinsic coagulation. This intrinsic coagulation causes major problems in medical surgery. Bypass surgery for example may not be conducted by replacing narrowed vessels with artificial vessels, which from a technical point of view would not cause any challenge.

Even though the start mechanism of the intrinsic and extrinsic coagulation process is different the result is the same. During the cascade of enzyme reactions Thrombin is produced and is able to modify fibrinogen by splitting off small particles of peptides in a way to start a polymerisation process. This polymerisation process is finally resulted in a network of insoluble fibrin fibres which are able to seal the defect.

Meaning of blood coagulation for the cleaning of MD's

Without the phenomenon of blood coagulation human blood would consist only of water soluble compounds and not cause any major problems during the cleaning of surgical instruments. The challenge for the cleaning process would be limited to the mechanical capabilities of the washer-disinfector to spread around enough water in the chamber of the washing machine to rinse all instruments. But there are around 5% of water insoluble blood components caused by the unavoidable coagulation process. Not only that coagulation forms water insoluble compounds on the surface of medical devices but these fibrin fibres are known for their mechanical stability which further complicates efficient cleaning.

Defibrinized dried blood can be removed from a stainless steel surface quite easily by rinsing with cold water whereas it takes much more time to rinse all water soluble proteins of coagulated dried blood because they are captured by the fibrin fibres. The cleaning kinetics of defibrinized vs. coagulated blood is shown in Fig. 1. Even more important is that observation of water without any mechanical support will not be able to achieve complete cleaning as the water insoluble fibrin fibres will stick on the surface.

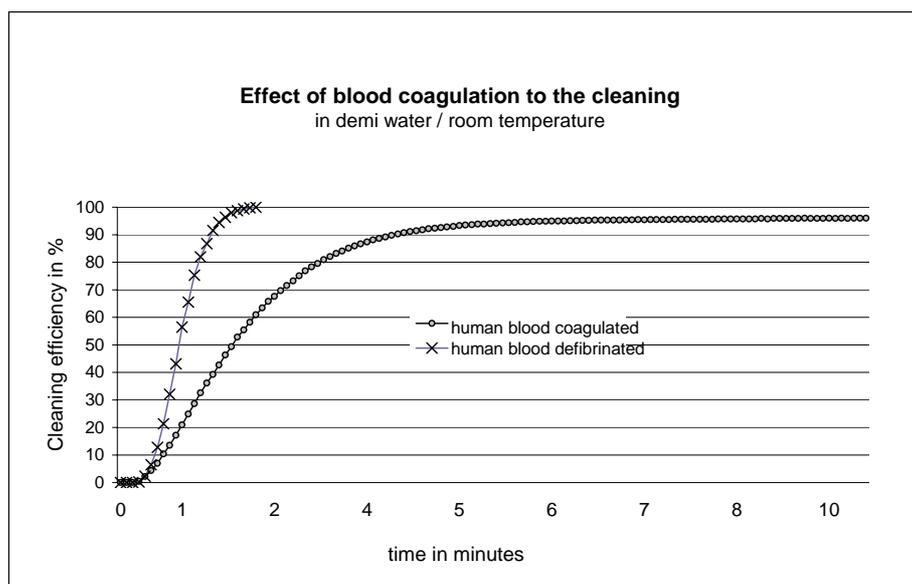


Fig. 1: Effect of blood coagulation to the cleaning

Proper cleaning of coagulated blood will require sufficient mechanical support. This will typically not cause any problems for surfaces which are directly exposed to the rinsing system of the washing machine, however it may result in significant deficiencies in areas where the mechanical impact of the machine is limited. Eg: in corners, or behind or under large instruments causing cleaning shades. As these effects cannot be avoided in a routine load, additional chemical support with cleaning detergents is required. Alkaline cleaners and enzymatic cleaners attack directly the peptide binding sites and should be able to also dissolve the water insoluble proteins like fibrin even without mechanical help. Neutral cleaners without enzymes however are not able to break up binding sites but support the mechanical cleaning through a reduction of the surface tension.

Important note: The lower the activity of the chemistry used the more mechanical activity will be needed for cleaning and the other way around.

Discussion

The specific characteristics of coagulated blood are frequently underestimated and do not get enough attention during the optimisation of cleaning programs. Some of the cleaning processes used in the reprocessing of medical devices are not capable to safely eliminate the water insoluble fibrin fibres. On the other hand there are existing controls to test surgical instruments to be free of proteins which are not even able to detect fibrin as the most critical blood component.

According to recommendations like from the German Robert-Koch-Institute risks for patients and personnel are not restricted to blood but may also be caused by blood components like fibrin. Fundamentally all reprocessing of medical devices must be conducted in a way to avoid any potential danger for patients, personnel or other third party. Cross-contaminations with protein residuals from a previous patient have to also be considered as unacceptable risk.

This raises the question about the responsibilities for efficient cleaning to whether it should be a requirement that a washer-disinfector has to produce clean instruments even without addition of chemical detergents? Or should it be a requirement to use only washing detergents which are able to clean medical devices without mechanical support of the washing machine? There will be situations where the best washing machine will fail without chemistry and there will also be situations where the strongest cleaner will need mechanical help to dissolve all contaminations. Most of the situations will become controllable after optimisation of chemistry and washing machine. There are a lot of easy ways to resolve wrong or insufficient program settings, like wrong temperature or too short time.

Most important is that the reprocessing of medical devices will stay in the responsibility of the CSSD. The head of the CSSD must define all reprocessing procedures and must guarantee clean medical devices and proper documentation of all relevant results and observations.