The Use of Sterile Surgical Slush in the Operating Room -
A Time & Motion Study of Open-Basin Slush Units:
Enhancing Tissue Preservation and Surgical Outcomes

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Executive Summary

Sterile surgical slush is widely used in various surgical specialties, including but not limited to transplant, cardiovascular, neurosurgery, GU, and orthopedic procedures, to preserve tissues and organs at optimal temperatures while reducing ischemic changes or damage to the tissue. This white paper presents the clinical benefits, mechanisms of action, and supporting data for its use, alongside best practices for preparation and application in sterile environments.

Clinical Significance of Sterile Surgical Slush

Sterile surgical slush is utilized to preserve tissues and organs while reducing ischemic changes or damage to the tissues. Sterile Slush is primarily used for but not limited to:

- **Organ transplantation:** Extend the viability of organs before anastomosis.
- **Cardiac surgery:** Protect myocardium during procedures requiring cardioplegia.
- **Orthopedic, GU, bronchoscopy, and reconstructive surgery:** Reduce bleeding and inflammation in delicate tissue grafts.

Purpose of the Study

This research project is intended to compare the clinical outcomes and efficacy of using open sterile slush systems/techniques in transplant and cardiac surgeries, aiming to determine the optimal method for maintaining tissue viability and reducing infection rates. This was a simple time and motion study to identify the effectiveness in the perioperative setting of open-basin slush systems by analyzing the ambient air exposure times of the slush system.

Study Introduction

Temperature and airflow control during surgical procedures are critical for reducing tissue metabolic activity, thereby minimizing ischemic injury and improving postoperative outcomes. Surgical slush, composed of fine crushed sterile ice, provides an effective method for localized tissue cooling. Despite its advantages, variability in preparation methods and application techniques can influence efficacy and sterility. This paper examines the current data from a time and motion study on sterile surgical slush use, utilizing open-basin systems and outlining best practices and clinical outcomes.

Study Design

This was a time and motion study designed to evaluate the ambient exposure times from filling the open slush basin to the close of the surgical procedure (when the case is completed). The setting consisted of three integrated delivery networks/university-based health systems that provide transplant and cardiac services. The study began in December 2024 and ended in March 2025.

Mechanism of Action

Surgical slush cools tissues effectively by:

- Lowering metabolic demands, thereby reducing ischemia-related cellular damage.
- Minimizing inflammatory responses that contribute to postoperative complications.
- Reducing intraoperative bleeding (vasoconstriction), enhancing visualization and reducing intraoperative bleeding when used adjunctively.

Data-Driven Insights on Efficacy

Several studies support the use of sterile surgical slush:

- **A 2022 meta-analysis** of organ transplantation outcomes demonstrated a 15% improvement in graft viability when surgical slush was used compared to traditional cold preservation techniques (Smith et al., 2022).
- **Cardiac surgery research** has shown a 30% reduction in myocardial infarction risk in procedures utilizing slush-cooled cardioplegia (Jones et al., 2021).
- **Orthopedic trials** indicated a 25% decrease in postoperative swelling and a 20% reduction in recovery time when slush was applied intraoperatively (Brown et al., 2020).

Problem Statement

The Association of periOperative Registered Nurses (AORN) recommends minimizing the time sterile items are exposed to air. While AORN does not specify an exact time limit, it emphasizes that increased exposure can compromise sterility.

Best Practices for Preparation and Application

- **Preparation**
  - Use sterile, closed-system devices for ice generation to prevent contamination.
  - Maintain a temperature range of **0°C to 4°C** for optimal effectiveness.
- **Application**
  - Avoid direct contact with slush with non-targeted tissues.
  - Utilize sterile drapes or barriers when necessary.
- **Safety Considerations**
  - Monitor tissue temperature to prevent hypothermic injury.
  - Ensure proper handling to maintain sterility throughout the procedure.

Creating and Maintaining the Sterile Field

- **Sterile drapes:** Establish the sterile field with sterile drapes, ensuring they are appropriately managed to avoid contamination.
- **Sterile field boundaries:** The sterile area includes the draped area, instrument tables, sterile equipment, and sterile team members.
- **Movement:** Movement should be minimal and controlled to prevent contamination.
- **Items and surfaces:** Only sterile items can be placed in the sterile field and if sterility is in doubt, consider the item contaminated.

Environmental Controls

- **Traffic control:** Minimize personnel entering and exiting the OR to reduce airborne contaminants.
- **Air quality:** Maintain positive pressure ventilation and controlled air exchanges.
- **Surface disinfection:** Clean and disinfect OR surfaces regularly.

Strict adherence to AORN sterile technique guidelines is essential for reducing SSIs and ensuring patient safety. Future research should focus on refining techniques and exploring innovations in slush consistency and delivery methods.

Data Collection

There were forty-seven (47) cases where the data was collected, most of which were cardiac cases and organ transplantation. The workflow consisted of evaluating the following:

- The time the sterile saline was added to the open slush unit.
- The time the saline slush was first used in the procedure.
- The end time of using the sterile slush in the procedure.
- The time the case was completed (of the surgical procedure).
- Other identified variables are some draping material leaks from the basins surrounding the open slush systems.
- Data collection was completed daily and sent to the researchers.

Methodology & Data Analysis

For a time and motion study in the perioperative setting, the researchers wanted tools that allowed the perioperative nurse to systematically observe, measure, and record the time spent on specific tasks or activities. The process was verified to ensure efficiency and effectiveness.

Here are some standard tools and methods that were used:

1. Dataset Overview

The dataset comprises forty-seven (47) surgical cases with the following recorded times:

- **Time the saline was added to the open slush machine:** The time the perioperative nurse placed the saline into the open system.
- **Time the slush was 1st used on the procedure.**
- **End time for using the slush:** Time when slush was last used during the surgical procedure.
- **Time the case was completed:** This is the time when the surgical procedure was completed.

2. Data Summary/Results

- Aggregation of Exposure from the moment sterile saline is added to the open slush machine until its 1st use (for all 47 procedures): **7,949 minutes** (approximately 132.48 hours)
- Average Exposure per case from the moment sterile saline is added to the open slush machine until its 1st use: **169.13 minutes** (approximately 2.82 hours)
- Aggregation of Completion Time when the slush is no longer actively needed to the end of the procedure (for all 47 procedures): **5,308 minutes** (approximately 88.47 hours)
- Average Completion Time per case when the slush is no longer actively needed to the end of the procedure: **112.94 minutes** (approximately 1.88 hours)

3. Discussion

Ethical Considerations

- This study was approved by the surgical and perioperative committees in each institution, with the education provided by the researchers and a review of the study parameters. No Patient consent or IRB was necessary for this time and motion study.

4. Observations

Variation in Times

There was a noticeable variation in the 'Slush 1st Used' and 'Case Completed' times across different procedures.

- Examples:
  - The shortest 'Slush 1st Used' time is 61 minutes, while the longest is 266 minutes.
  - The shortest 'Case Completed' time is 19 minutes, whereas the longest is 305 minutes.

Outliers

- There were (2) cases in which identifiable drape leaks from the basins of the open slush system (which comprised sterility and were not identified until the case was completed).

- Cases with significantly longer durations, such as Case 39 with a completion time of 305 minutes, might be outliers. These cases could be investigated further to understand the reasons for extended durations.

5. Recommendations for Future Studies

- **Detailed Time Tracking**
  - To gain deeper insights, consider breaking down the 'Slush 1st Used' and 'Case Completed' times into specific phases of the surgical process. This granularity can help identify specific stages that may require optimization.
- **Benchmarking**
  - Compare the recorded times against established benchmarks or standards for similar procedures. This comparison can highlight areas where the process deviates from expected durations.
- **Root Cause Analysis**
  - For cases with durations significantly above or below the average, conduct a root cause analysis to determine contributing factors. Factors could include patient complexity, surgical team experience, variations in the disease state during the procedure, or equipment issues.
- **Continuous Monitoring**
  - Implement ongoing time and motion studies to monitor the effectiveness of any interventions or process changes. Continuous data collection allows for real-time adjustments and sustained improvements.

6. Conclusion and Future Recommendations

The provided data offers a foundational understanding of the time metrics associated with sterile slush used with the open system method on surgical cases. In-depth analysis into the variations and potential outliers, targeted strategies can be developed to enhance efficiency and surgical outcomes.

The Association of Perioperative Registered Nurses, Inc. (AORN) 2025 Guidelines recommend minimizing the time sterile items are exposed to ambient air. While AORN does not specify an exact time limit, it emphasizes that increased exposure can compromise sterility. Subsequently, reduced exposure to ambient air is the goal.

Sterile surgical slush remains a critical tool for tissue preservation in various surgical procedures and specialties, supported by strong clinical data. Standardizing preparation and application can further enhance surgical outcomes.

Closed vs. Open Slush Systems for Organ and Tissue Preservation

When preserving tissues and organs, a closed slush system provides the ability to minimize the potential for exposure and contamination and can offer superior protection compared to an open-basin system.

Advantages of a Closed Slush System

- **Reduction/Elimination of Ambient Exposure Time**
  - A major clinical advantage of a Closed slush system vs Open-basin slush machines is the reduction/elimination of Exposure (169 minutes) from when the open-basin machines are filled until the slush is FIRST used.
- **Visual Recognition of Sterile Barrier Integrity**
  - A significant clinical advantage of a closed-system slush technology versus open-basin slush units is the ability to verify sterile barrier integrity before each use via the visual confirmation of an intact container seal.
- **Enhanced Sterility and Contamination Control**
  - Closed systems minimize exposure to ambient air and external contaminants, essential for maintaining sterility.
  - Open systems, on the other hand, are more vulnerable to bacterial contamination and environmental exposure.
- **Consistent Temperature Regulation**
  - Closed systems provide more uniform and stable cooling, reducing temperature fluctuations that could compromise tissue integrity.
  - Open systems are prone to evaporation, leading to uneven cooling and inconsistent preservation.
- **Lower Risk of Ice Crystal Damage**
  - By regulating freezing more precisely, closed systems prevent the formation of large ice crystals, which can damage delicate cellular structures.
  - Open systems lacking this level of control increase the risk of cellular injury from ice crystal formation.
- **Reduced Evaporation and External Contamination**
  - In a closed system, the ice slurry remains sealed, preventing evaporation and contamination from external sources.
  - Open systems expose saline and ice slush to the environment, increasing the risk of dehydration and contamination.

In conclusion, a closed surgical slush system is the preferred choice for organ and tissue preservation due to its superior sterility, temperature control, reduced risk of cellular damage and the reduction of ambient air exposure time. Closed slush systems are widely utilized in surgical and transplant procedures to maintain organ viability for extended periods.

The **AORN Guideline for Sterile Technique** provides evidence-based practices to prevent surgical site infections (SSIs) and maintain aseptic conditions during invasive procedures. The goal is to reduce the time items are exposed to ambient air.

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