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Analysis of the Impact of Sterilization Qualification Rate of Disinfection Supply Center Equipment on Infection Occurrence in Geriatrics Department

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Abstract: As a critical department ensuring the sterility of hospital instruments, the Sterile Supply Center (SSC) directly impacts the sterility status of clinical instruments through its sterilization qualification rate. Geriatric patients, due to physiological decline and compromised immune function, constitute a high-risk group for hospital-acquired infections, with more stringent requirements for instrument sterility. This paper analyzes the current status and influencing factors of sterilization qualification rates in SSCs, explores the mechanistic association between sterilization qualification rates and infections in geriatric departments, and proposes targeted strategies to improve sterilization qualification rates. It highlights the pivotal role of SSC instrument sterilization in infection prevention and control for geriatric patients, providing theoretical basis and practical guidance for optimizing SSC management, reducing infection rates in geriatric departments, and ensuring the safety of elderly patients' medical care. These findings aim to enhance overall infection management standards in hospitals.

Keywords: Central sterile supply (CSS); Sterilization compliance rate of medical devices; Geriatrics department; Hospital-acquired infections (HAI); Infection prevention and control

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1. Introduction

Hospital-acquired infections (HAIs) represent a significant challenge in contemporary hospital management and a critical factor affecting healthcare quality. With the advancement of modern medical technologies, the widespread clinical application of numerous chemotherapeutic immunosuppressants, the increase in invasive procedures, the misuse of antimicrobial agents, and the aging population, these factors collectively contribute to the rising trend

of HAIs. The prevention and control of HAIs are central to healthcare quality and patient safety management, with instrument sterility being a key element in interrupting pathogen transmission and preventing infections. The Central Sterile Supply Department (CSSD) is responsible for the cleaning, disinfection, and sterilization of reusable medical devices across the hospital, and its sterilization compliance rate serves as a critical indicator of the foundational capabilities in HAI prevention and control. Geriatric patients, who are typically elderly and often comorbid with underlying conditions, have weakened immune defenses. The use of sterilization-defective instruments can easily lead to various HAIs, which may not only exacerbate the patient's condition but also pose life-threatening risks in severe cases. Some hospitals' CSSDs exhibit management deficiencies in the sterilization process, resulting in unstable sterilization compliance rates, thereby creating potential risks for geriatric infections. A systematic analysis of these factors holds significant clinical and managerial value.

2. Current status and influencing factors of sterilization compliance rate for medical devices in central sterile supply units

2.1. Current status of sterilization compliance rate for medical devices

Although some hospital disinfection supply centers have established basic procedures for instrument sterilization, the actual sterilization qualification rate still exhibits fluctuations. Certain hospitals lack comprehensive monitoring of sterilization quality, relying solely on physical and chemical monitoring during the sterilization process without emphasizing microbiological sampling of sterile items after storage. This results in substandard sterilized instruments potentially entering clinical settings. In some primary or older hospitals, disinfection supply center equipment updates are delayed, with sterilizers showing signs of aging and performance instability, potentially leading to suboptimal sterilization temperatures or insufficient sterilization time, directly affecting the efficacy of instrument sterilization. Additionally, some disinfection supply center staff exhibit lapses in adhering to sterilization protocols, such as exceeding instrument loading density limits or incorrectly setting sterilization parameters. These issues further hinder the maintenance of a consistently high sterilization qualification rate, posing risks to infection control in clinical departments, particularly geriatric care units.

2.2. Key factors affecting sterilization compliance rate of medical devices

Sterilization of surgical instruments is a critical measure for preventing hospital-acquired infections and a primary strategy to reduce infection rates. The effectiveness of sterilization for medical devices entering human tissues and organs directly impacts the threat of blood-borne diseases to public health. Thorough cleaning is a prerequisite for qualified sterilization, and the complete cleaning of surgical instruments is as important as disinfection and sterilization, as inadequate cleaning can compromise the efficacy of these processes. However, due to varying conditions and facilities across hospitals in China, the methods for cleaning and disinfecting surgical instruments differ. As a systematic task, the qualification rate of instrument sterilization is influenced by multiple factors. First, the quality of instrument cleaning: residual blood, tissues, or other organic matter not fully removed after use can form a "biofilm", hindering the action of sterilization agents. Some staff members may underestimate the importance of the cleaning phase, leading to simplified procedures or misuse of cleaning tools, which negatively affect subsequent sterilization outcomes. Second, the management of sterilization equipment and consumables: failure to perform regular maintenance and calibration of sterilizers or to conduct standardized performance verification can result in malfunctions such as temperature sensor failures. Additionally, inappropriate selection of

sterilization packaging materials or poor sealing performance may lead to contamination of sterilized instruments during storage or transportation. Finally, the standardization of personnel operations: some staff members lack a solid understanding of sterilization principles and the specific requirements for different types of instruments. Deviations in key operational aspects, such as instrument classification, loading density control, and sterilization parameter settings, can further compromise sterilization efficacy and cause fluctuations in the qualification rate.

3. Mechanism of the impact of sterilization compliance rate of medical devices in the central sterile supply unit on infection incidence in geriatrics

3.1. Sterile non-compliant instruments directly cause infections in geriatrics departments

In geriatric patient care, surgical instruments, puncture needles, urinary catheters, suction tubes, and other medical devices are frequently used. If these instruments fail to meet sterilization standards, residual pathogens such as bacteria, fungi, and viruses on their surfaces can be transmitted to patients through direct contact. The use of inadequately sterilized instruments during surgery allows pathogens to invade tissues via surgical incisions, leading to surgical site infections. Elderly patients have weaker wound healing capabilities, making them prone to post-infection complications such as wound redness, exudation, and delayed healing. In severe cases, systemic infections may develop. For elderly patients requiring long-term urinary catheterization, exposure to substandard sterilized catheters can introduce pathogens into the urethra, compromising the mucosal barrier and causing urinary tract infections. Additionally, the degeneration of urinary system function in elderly patients increases the likelihood of recurrent infections and complicates treatment. Substandard sterilized instruments serve as direct carriers of pathogens, constituting a significant predisposing factor for infections in geriatric care.

3.2. Increased variability in sterilization compliance rate and challenges in infection prevention and control in geriatrics

The long-term instability of sterilization compliance rates in the disinfection supply center compromises the sustained sterility of medical devices used in geriatric departments, leaving infection control efforts vulnerable to passive responses [1]. During periods of declining compliance rates, geriatric departments may experience multiple unexplained infections within a short timeframe. Given the concealed nature of sterilization issues, tracing infection sources in the early stages proves challenging, potentially leading to wider infection spread. To address fluctuations in sterilization compliance, geriatric departments must enhance infection monitoring frequency and adjust preventive measures, such as conducting secondary disinfection of used devices and strengthening patient infection screening. These measures increase the workload of healthcare staff and may delay optimal infection control opportunities due to untimely adjustments. The instability of sterilization compliance rates disrupts the continuity of infection prevention in geriatric departments, further elevating infection risks.

3.3. Low sterilization compliance rate affects overall diagnostic and therapeutic safety in geriatrics

A persistently low sterilization compliance rate for medical devices can have ripple effects on the overall safety of geriatric care. Frequent infection incidents may erode trust in hospital services among patients and their families, ultimately damaging the institution's reputation. Elderly patients requiring additional anti-infective therapy often experience aggravated underlying conditions, such as dramatic blood glucose fluctuations in diabetic patients or

heart failure in cardiovascular patients. This not only increases medical costs but also prolongs hospital stays, consuming limited healthcare resources. Should mass infections occur due to substandard sterilized equipment, it may trigger medical disputes and disrupt routine clinical operations. The low sterilization compliance rate indirectly compromises hospital quality and operational efficiency by compromising geriatric care safety.

4. Strategies to improve the sterilization compliance rate of instruments in the central sterile supply unit

4.1. Improve the quality management system for the entire process of instrument sterilization

The device recycling process requires the establishment of a classified recycling system to avoid mixing devices of different contamination levels, thereby reducing the risk of cross-contamination. Devices used by patients with specific infections must undergo closed-loop recycling and special labeling management to achieve risk control at the source. The cleaning process implements a standardized "cleaning-rinse-end rinse" procedure, equipped with dedicated cleaning equipment and agents. Complex devices such as arthroscopes and staplers are cleaned manually with assistance, while technologies like ATP biofluorescence detection are employed to objectively evaluate cleaning effectiveness, ensuring complete removal of organic matter. The sterilization process strictly adheres to a triple-monitoring system combining physical, chemical, and biological monitoring. Physical monitoring records parameters such as sterilization temperature, time, and pressure. Chemical monitoring involves attaching chemical indicator tape to each package of devices and placing chemical indicator cards inside the packages. Biological monitoring is conducted weekly, and a traceability mechanism linking monitoring results to sterilization batches must be established to ensure traceable sterilization efficacy and accountability [2]. A quality supervision team is formed to conduct regular spot checks on the quality of each process. Information systems are utilized to achieve electronic recording and analysis of quality data throughout the entire process, enabling data trend analysis to identify and address potential risks in a timely manner, ensuring controllable sterilization processes and continuous quality improvement.

4.2. Strengthen standardized management of sterilization equipment and consumables

Professional technicians must be regularly invited to perform maintenance and performance calibration of the sterilizer. A comprehensive equipment performance verification should be conducted annually to ensure that the sterilizer's temperature control accuracy, vacuum level, and steam quality meet standard requirements. Performance testing must be repeated after each equipment repair or key component replacement to prevent "operation with malfunctions". An equipment operation record should be established, detailing each usage time, sterilization batch, fault conditions, and repair information to facilitate traceability of equipment status. Additionally, a no-load B-D test should be performed daily before operation to verify the cold air exhaust efficiency of the pre-vacuum pressure steam sterilizer, ensuring the equipment operates at optimal conditions. In terms of consumable management, strict screening of sterilization packaging material suppliers is required, with non-woven fabrics and paper-plastic packaging bags compliant with national quality standards selected to ensure adequate barrier properties and breathability. A supplier quality evaluation and exit mechanism should be established, with quality sampling conducted before use to identify issues such as damage or poor sealing. Single-use sterile packaging materials must undergo strict access management and batch traceability. Sterilized

items should be stored according to specifications, with control over storage environment temperature, humidity, and ventilation conditions. The "first-in-first-out" inventory management principle should be implemented, with regular checks on the validity period of sterile items and packaging integrity to prevent packaging damage or microbial contamination during storage. This ensures reliable sterilization compliance from both equipment and consumable perspectives [3].

4.3. Strengthening the professional competency development of personnel in the central sterile supply unit

A tiered training program has been established, requiring new staff to undergo 3–6 months of systematic pre-job training. The curriculum covers principles of instrument cleaning and sterilization, operational protocols, infection control knowledge, and equipment usage methods, adopting a "theory + practice + on-the-job training" model. Experienced senior staff serve as mentors for one-on-one guidance, with independent job placement contingent upon passing assessments. On-duty personnel participate in quarterly professional training sessions to update their expertise in line with the latest industry standards and guidelines. These include interpreting new requirements of the "Hospital Sterile Supply Center Management Standards", learning advanced precision instrument handling and sterilization procedures, and incorporating interactive teaching methods such as case discussions and scenario simulations [4]. Regular skill operation assessments and case analysis meetings are organized to enhance staff's practical abilities and problem-solving skills through simulated instrument cleaning and sterilization operations and analysis of sterilization non-compliance cases. Assessment results are linked to job authorization, establishing a scientific performance evaluation mechanism. Key indicators such as sterilization compliance rate, adherence to operational protocols, and quality defect detection rate are incorporated into the evaluation system. Assessment outcomes correlate with performance distribution, excellence awards, and professional title promotions, incentivizing staff to shift from "quality demanded" to "quality desired", fostering a positive work culture and cultural awareness of "quality-focused, quality-driven" practices.

5. Conclusion

The sterilization compliance rate of medical devices in the Central Sterile Supply Unit (CSSU) is directly and closely associated with the incidence of infections in geriatric departments, with its level determining the robustness of the foundational defense against geriatric infections. Currently, some hospitals exhibit management deficiencies and operational issues in the sterilization of CSSU devices. These problems need to be addressed by improving the comprehensive quality management system, enhancing the management of equipment and consumables, and strengthening the professional training of personnel. Improving this compliance rate can reduce the incidence of geriatric infections, ensure patient safety in diagnosis and treatment, and promote the refined development of hospital infection control. Hospitals should continue to focus on sterilization quality, incorporate it into the infection control strategy, optimize relevant measures to achieve stable improvement in compliance rates, and provide strong support for infection prevention and control.

Disclosure statement

The authors declare no conflict of interest.

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