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ORIGINAL RESEARCH

A Summary of the Best Evidence for Wet Pack Management

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Background: Wet pack after steam sterilization of medical devices in healthcare facilities are unacceptable.

Purpose: To retrieve, evaluate and integrate the best evidence related to wet pack management.

Methods: We searched the JBI, Up To Date, BMJ, National Guideline Clearinghouse (NGC), National Institute for Health and Care Excellence (NICE), Scottish Intercollegiate Guidelines Network (SIGN), Cochrane library, PubMed, Guideline International Network (GIN), AORN Journal, and other databases using the pyramid "6S" model for guidelines, expert consensus, systematic reviews, evidence summaries, decisions, recommended practices, and technical reports on wet pack management. The period of the literature search is from the establishment of the database to January 2024. Two researchers evaluated the literature quality independently, and evidence was extracted from the literature that met the quality standards. AGREE II assessment system, Cochrane bias risk assessment, and JBI Evidence-Based Health care center authenticity assessment were used as the literature evaluation criteria and the JBI 2014 edition evidence pre-grading system for intervention studies. For all types of research, the literature quality and evidence level was evaluated, extracted, and summarized according to the theme.

Results: Based on the inclusion criteria, seven pieces of literature were selected, including three guidelines, three randomized controlled trials, and consensus from an expert. Twenty pieces of evidence were obtained from seven different aspects: device packaging stage, loading stage, sterilization stage, unloading and cooling stage, distribution stage, wet package evaluation and analysis, and personnel training.

Conclusion: This study summarizes the best evidence on wet pack management and can provide a reference for staff practices in disinfection supply centers to reduce the incidence of wet packs.

Keywords: wet pack, prevention, management, evidence-based nursing, summary of evidence

Introduction

According to the Chinese health industry standard, "Hospital Disinfection Supply Center Part II: Technical Operation Specifications for Cleaning, Disinfection and Sterilization", wet packs are defined as sterilization packs that are visible to the naked eye after sterilization and cooling, such as damp and water inside or outside the pack. Additionally, it is required that sterile items be checked for a wet pack upon unloading. Wet packs should not be stored and distributed; they should be analyzed and improved.[1] According to the relevant guidelines, such as the American Association for the Advancement of Medical Devices and the Centers for Disease Control and Prevention, the wet pack occurs after the sterilization cycle is finished if moisture, water droplets, or small water droplets form on or inside the pack. Furthermore, it stipulates that the wet pack is an unqualified package that cannot be directly distributed and must be sterilized again.[2,3] Due to the humid internal and external environment, the wet pack can form an internal and external channel following the siphon principle. This provides a liquid channel for the entry of external microorganisms and is susceptible to secondary pollution, leading to hospital-acquired infection. The wet pack was found to be a failure of sterilization. As a result, the wet pack must be reprocessed, delaying the normal supply of sterile instruments and affecting the surgical process as well as the quality of diagnosis and

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treatment in clinical departments. Simultaneously, repeated sterilization of instruments is a waste of hospital manpower, material, and financial resources. Studies reported that the incidence of the wet pack in China was 1.67%-19.7%,[4,5] most of which occurred when the lower-row sterilizer was used and there was no drying procedure.[6] Other studies have shown that wet items, non-standard packaging, unreasonable loading, and sterilizer failure are all caused due to the wet pack.[7,8] It is also related to the failure of a valve of the sterilization vessel, poor quality of steam, and unreasonable design of the sterile storage area.[9] There are many studies on reducing the incidence of wet packs in China. Some studies found that changing the loading mode and excluding sterilizer failure reduced the incidence of wet packs.[10] Researchers also showed a significant reduction in wet packing incidence by changing steam quality and packaging methods.[11] Furthermore, Sun et al[12] adopted the FOCUS-PDCA management method to significantly reduce the incidence of the wet pack of loaned medical instruments. The research by Ouyang et al[13] indicated that when the drying time of the sterilizer could not be determined, the department should offer the sterilization parameters that could be provided by the sterilizer of this hospital to the manufacturer and conduct wet pack verification. However, most are based on experiential and exploratory management methods without evidence-based scientific and systematic research. To further establish a standardized wet pack management program, this study aims to summarize the best evidence for wet pack management programs using evidence-based nursing methods. To provide a decision-making basis for disinfection and sterilization practitioners by clarifying the key tasks in the equipment packaging stage, loading stage, sterilization stage, unloading and cooling stage, distribution stage, wet pack evaluation and analysis stage, and personnel training. Finally, by narrowing the gap between research and practice, the effectiveness and standardization of disinfection and sterilization practices can be improved to ensure the quality of sterilization and reduce the incidence of the wet pack.

Materials and Methods

Establishment of the Evidence-Based Panel

The evidence-based team comprised eight members: two CSSD nurses, two graduate students, two evidence-based experts, and two managers. Among them, two nurses in CSSD were responsible for literature screening, quality evaluation, and evidence extraction. Two graduate students were responsible for the integration and induction of evidence. The literature search and evidence integration were guided by two evidence-based experts. The project coordination and quality control were handled by two managers.

Definition of Evidence-Based Practice Problems

The PIPOST model, an evidence-based problem-setting tool of the evidence-based nursing center of Fudan University, was used to define the evidence-based problem of this project. The PIPOST model refers to population, intervention, professional, outcome, setting, and type of evidence. In this study, P represents the sterilization package, I represents wet pack management measures, including the wet pack processing process and wet pack cause analysis. P also represents CSSD staff, including nurses and mechanics. O represents the primary outcome, ie, the incidence of the wet pack. The secondary outcome indicators are included as follows: 1. The awareness rate and implementation rate of evidence related to wet pack management among the staff; 2. The system, namely wet pack processing specification rate. S represents sterile supply center, T represents guidelines, evidence summary, systematic review, expert consensus, and original study.

Search Strategies for Evidence

We searched the Joanna Briggs Institute (JBI), Up To Date, Best Practice (BMJ), National Guideline Clearinghouse (NGC), National Institute for Health and Care Excellence (NICE), Scottish Intercollegiate Guidelines Network (SIGN), Cochrane Library, PubMed, Guideline International Network (GIN), AORN Journal, and Registered Nurses Association of Ontario (RNAO), OVID, China Biology Medicine (CBM), China National Knowledge Infrastructure (CNKI), Wanfang Knowledge Service Platform, China Science and Technology Journal Database, and Yimaitong databases using the pyramid "6S" model for guidelines, expert consensus, systematic reviews, evidence summaries, decision making, recommended practices, and technical reports on wet pack management. The search time ranged from the establishment of the database to January 2024.

Using the combination of subject words and free words to construct the English search formula: (wet load "OR" wet pack "OR" wet item "OR" failed. Sterilization load OR sterilize*) AND ("guideline "OR" practice "OR" recommendation "OR" standard "OR" consensus") AND ("management" OR "prevention" OR "reprocessing"). Chinese search formula: ("wet pack 'OR' wet load 'OR' sterilization") AND ("guidelines 'OR' evidence summary 'OR' systematic review 'OR' review 'OR' meta-analysis 'OR' meta-analysis 'OR' expert consensus") AND ("management 'OR' management 'OR' prevention").

Evidence-Based Inclusion and Exclusion Criteria

The PIPOST model was used to determine the specific questions of evidence summary, as well as the inclusion and exclusion criteria of the literature. Inclusion criteria: ① The subjects used wet packs; ② The research content includes wet pack management, wet pack treatment, cause of wet pack analysis, and preventive measures; ③ Evidence types include guidelines, expert consensus, systematic reviews, evidence summary, randomized controlled trials, etc. Exclusion criteria: ① Incomplete data reported in the literature; ② Low-quality literature after quality evaluation; ③ Updated guidelines or systematic reviews; (4) Articles published repeatedly with the same content; ⑤ Only the summary or translation version of the guideline consensus was used.

Literature Quality Evaluation Criteria and Procedures

Tools for evaluating quality were selected based on the type of literature. ① The AGREE II evaluation system was used to evaluate the guidelines. Each item is given a score of 1 to 7 on a scale, with 1 indicating that the guideline does not meet the item at all and 7 indicating that the guideline does meet the item at all. The higher the score, the higher the quality of the guideline. Grade A (recommended): the score of six domains in the guideline is ≥60%, which has not been altered or specifically recommended. Grade B (recommended after different degrees of modification): the number of fields with a score of ≥30% is ≥3, but there are <60% of fields that need to be revised and improved. Grade C (not recommended): the number of domains with a score of <30% is ≥3, which is not recommended for the time being. ② The quality of randomized controlled trials (RCT) was evaluated using the Cochrane bias risk assessment tool. The tool contained 7 items, and the assessors were asked to rate each item as "low risk of bias", "high risk of bias", or "unclear". ③ The authenticity evaluation tool developed by JBI Evidence-Based Health Care Center was used to assess the quality of expert consensus. The tool contains six items, and the evaluator must assign a value of "yes", "no", "unclear", and "not applicable" for each item. Finally, the inclusion of the literature was decided after an evidence-based group discussion.

Two nurses with an evidence-based nursing background in CSSD independently completed the quality evaluation of the included literature. CSSD managers participated in the discussion when it was unclear whether they should be included in this study or when there were disagreements among evaluation opinions. After summarizing the opinions, two evidence-based experts decided whether to include the article or obtain further information. When different sources of evidence produce conflicting conclusions, the inclusion principles of this study are evidence-based evidence, high-quality evidence, and the latest published authoritative literature.

Induction and Grading of Evidence

Two graduate students with backgrounds in evidence-based medicine and nursing extracted and integrated evidence independently. The following principles were used to integrate evidence. ① When the content of evidence is consistent, the evidence that conforms to professional expression and is simple to understand is preferred. When "instrument package should not exceed 7 kg, dressing package should not exceed 5 kg" and "sterilization package should not be too large and heavy", the former is preferred. ② When the evidence content is complementary, it is combined according to the logical relationship of the evidence. It is suggested to "Use a special sterilization rack or sterilization basket to load the sterilized items when the instrument is loaded, and leave a gap of 2.5 cm between the sterilization packages". ③ When evidence is inconsistent, high-quality evidence should be given priority. ④ The evidence content was classified using the JBI 2014 intervention research evidence pre-grading system, classifying the evidence from Level 1 to Level 5 from high to low. The more rigorous the study design, the higher the level of evidence.

Results

The Screening Process of Evidence

A total of 842 pieces of literature were preliminarily retrieved, and the literature was screened based on the inclusion and exclusion criteria. After quality evaluation, seven articles were finally included. Among them, there were three guidelines,[2,11,12] three randomized controlled trials,[14–16] and one expert consensus.[17] Figure 1 depicts the literature screening process, and the basic information of the included literature is shown in Table 1.

Results of Evidence Quality Evaluation

Results of the Evaluation of Guidelines

As shown in Table 2, three guidelines were included,[2,11,12] with 1 Grade A guideline and 2 Grade B guidelines of high overall quality, and were approved for inclusion.

Results of Randomized Controlled Trial Evaluation

A total of three articles were included.[14–16] According to the Cochrane bias risk assessment tool, three randomized controlled trials[14–16] were finally included, as shown in Table 3.

Results of Expert Consensus Evaluation

As shown in Table 4, only one expert consensus was included [29]. The evaluation results of some items were "no" or "unclear", and the overall quality was high, so it was approved for inclusion.

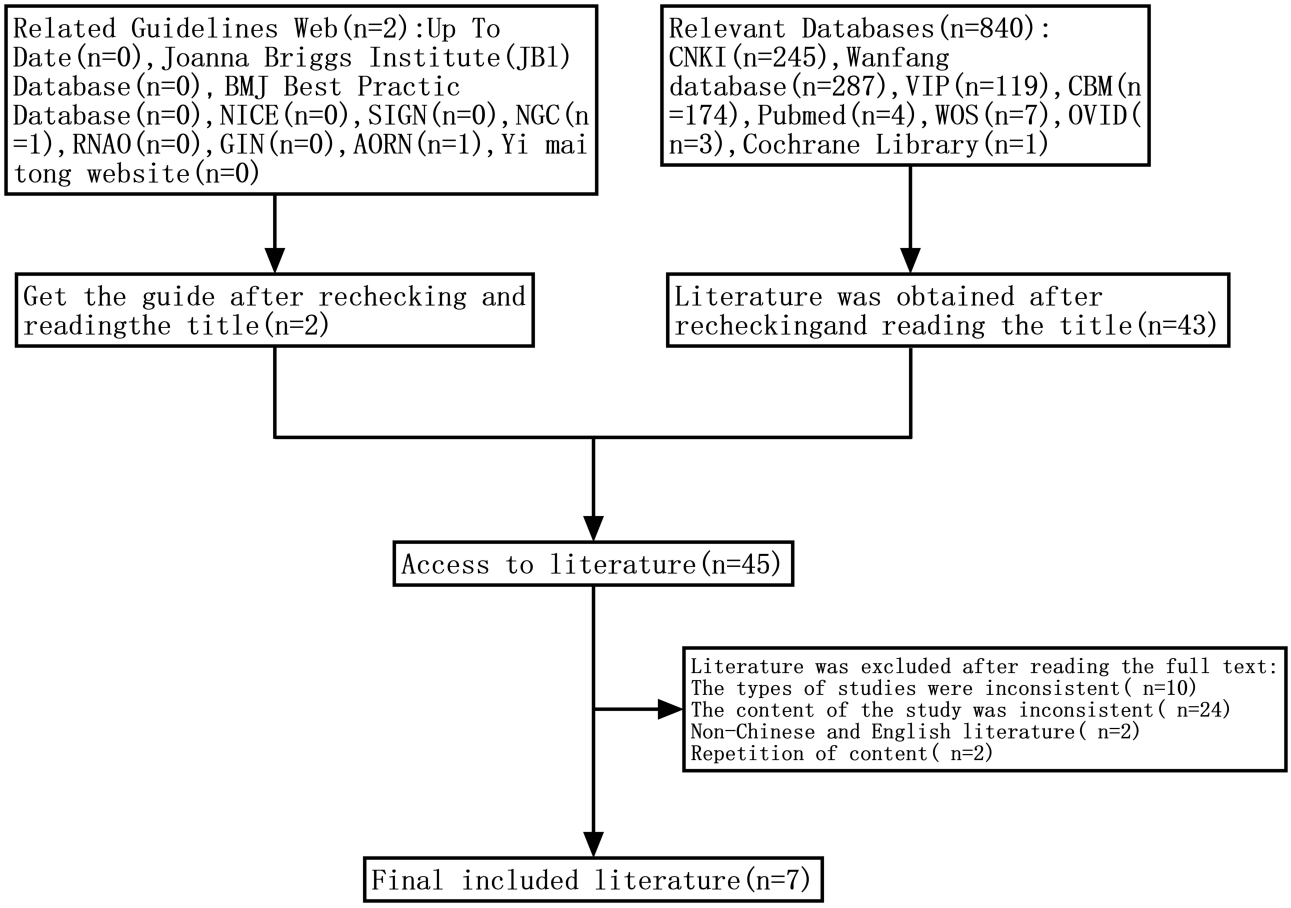

Figure 1 Flow chart of literature screening.

Table 1 Basic Information of the Included Literature

Included Literature	Literature Sources	Content of Literature	Type of Literature
Ling[12]	PubMed	APSIC guidelines for the disinfection and sterilization of medical instruments in institutions	Guideline
Guideline for Sterilization[13]	AORN	Guidelines for AORN sterilization	Guideline
AMMI[2]	NGC	Guidelines for disinfection and sterilization processes in medical and health institutions	Guideline
Dong et al[14]	CNKI	Application and effect evaluation of infrared thermometer in cooling temperature monitoring following sterilization	RCT
Xu et al[15]	CNKI	Effect analysis of sterilization loading methods on the wet pack of paper-plastic packaging equipment	RCT
Yuan et al[16]	CNKI	An investigation into the impact of packaging materials and packaging methods on wet pack	RCT
Barbosa Rodrigues S[17]	PubMed	Expert views on factors associated with the wet pack after steam sterilization	Expert consensus

Table 2 Results of the Methodological Quality Assessment of the Guidelines

Included Guidelines	Percentage of Standardization in Each Field (%)						Total Score of Quality Evaluation (Score)	Recommended Grade
	Scope and Objective	Personnel	Rigor of Rigour	Clarity of Articulation	Applicability	Independence		
Ling[12]	88.89%	83.33	71.35	86.11	55.21	87.50	All ≥5	B
Guideline for Sterilization[13]	80.56	69.44	43.75	55.56	32.29	81.25	All ≥5	B
AMMI[2]	93.06	95.83	82.29	87.50	69.79	95.83	All ≥5	A

Table 3 Results of Methodological Quality Assessment of Randomized Controlled Trials

	Evaluation Results (High/Low/Unclear)					
	Dong et al[14]		Xu et al[15]		Yuan et al[16]	
	A	B	A	B	A	B
1. Generation of random sequences	Low	Low	Low	Low	Low	Low
2. Concealment of randomization assignments	High	High	High	High	High	High
3. The subjects and the interveners were blinded	Low	Low	High	High	High	High
4. The outcome assessors were blinded	High	High	High	High	High	High
5. Completeness of endpoint data (loss to follow-up)	Low	Low	Low	Low	Low	Low
6. The possibility of selectively reporting research findings	Low	Low	Low	Low	Low	Low
7. Other sources of bias	Unclear	Unclear	Unclear	Unclear	Unclear	Unclear
8. Overall evaluation	Inclusion		Inclusion		Inclusion	

Note: A and B are two evaluators.

Table 4 Results of the Methodological Quality Assessment of the Expert Consensus

	Evaluation Result (Yes/No/Unclear)	
	Barbosa Rodrigues[17]	
	A	B
1. Is the source of the opinion identified?	Yes	Yes
2. Are the views expressed by influential experts in the field?	Yes	Yes
3. Are the views presented to study the relevant population interests?	Yes	Yes
4. Is the conclusion of the statement based on the results of the analysis, and is the argument logical?	Yes	Yes
5. Did you refer to other literature?	Yes	Yes
6. Do the ideas presented contradict previous literature?	No	No
Overall evaluation	Inclusion	Inclusion

Note: A and B are two evaluators.

Summary of Evidence

Finally, 20 pieces of best evidence were drawn from seven aspects, including the packaging stage, loading stage, sterilization stage, unloading and cooling stage, distribution stage, wet pack evaluation and analysis, and personnel training, as shown in Table 5.

Recommendations for Practice

The stages of packaging, loading, sterilization, unloading, cooling, and distribution must all follow a scientific and planned operation process. Simultaneously, when a wet pack occurs, a multidisciplinary team should work together to analyze the causes of the wet pack using a wet pack evaluation checklist and flow chart, and relevant measures to reduce the occurrence of the wet pack should be formulated.

Discussion

Quality Control Before Sterilization Can Help to Reduce the Risk of Wet Bags

Packing before sterilization is the most basic safeguard against wet packs. The first line of evidence in this study clarifies the weight and volume of the sterile package. It has been reported that controlling the size and weight of sterile packs can

Table 5 Summary of the Best Evidence for Wet Pack Management

Themes of Evidence	Description of Evidence	Source	Type of Literature	Level of Evidence
Packaging stage	1. Standardize the weight and volume of the sterilization package. The instrument package weight should not exceed 7 kg, and the weight of the dressing package should not exceed 5 kg. The sterilization volume of the pre-vacuum pressure steam sterilizer should not exceed 30 cm x 30 cm x 50 cm. The sterilization volume of the lower exhaust pressure steam sterilizer should not exceed 30 cm x 30 cm x 25 cm.[2,12,13,16]	CNKI PubMed AORN NGC	RCT Guideline Guideline Guideline	Level 2
	2. Choose the right packing material. Double-layer non-woven fabric is recommended for instrument packs. The inner layer of the dressing package was cotton cloth, and the outer layer was non-woven cloth. Single-package or smaller precision instruments should be packaged using paper-plastic.[2,12,13,16]	CNKI PubMed AORN NGC	RCT Guideline Guideline Guideline	Level 2
	3. Choose appropriate absorbent materials in the package based on packaging material, such as disposable absorbent paper and absorbent pad.[2,12,13,]	PubMed AORN NGC	Guideline Guideline Guideline	Level 2
	4. The instruments have been disassembled and reassembled by the specifications[2,12,13]	PubMed AORN NGC	Guideline Guideline Guideline	Level 2
Loading stage	5. Sterilize items with the same sterilization parameters in the batch. In the case of mixed loading, textile items are placed in the upper layer, whereas instrument items are placed in the lower layer.[12,17]	PubMed	Guideline and expert consensus	Level 2
	6. When the special sterilization rack or basket is used to load the sterilized items, there is a gap of about 2.5 cm between the sterilization packages.[12]	PubMed	Guideline	Level 2
	7. Paper packs and paper-plastic packaging items are placed on the side, with the paper side down rather than stacked together, and water-absorbing liners are used.[12,15]	PubMed CNKI	Guideline RCT	Level 2
	8. The packaging does not touch the wall of the sterilizer and stays away from the bottom floor (vent).[12,17]	PubMed	Guideline and expert consensus	Level 2
	9. The surgical instrument package and hard container should be placed flat, and the basin, plate, and bowl should be oblique. Glass bottles and other utensils without holes in the bottom are placed upside down or on the side.[12,13]	PubMed AORN	Guideline Guideline	Level 2
Sterilization stage	10. The sterilization drying time should be determined following the manufacturer's instructions. The drying time specified in the device manufacturer's instructions was consistent with the actual sterilization time.[12,13,15]	PubMed AORN CNKI	Guideline Guideline RCT	Level 1 Level 1
	11. The steam sterilizer manufacturer must determine the key parameters and ranges of the sterilization process. For example, the number of pulses in the conditioning phase, temperature, exposure and drying time, steam injection rate, and input pulses of filtered air in the drying phase. One needs to pay attention to the quality of steam, and the proportion of non-condensing gas must not exceed 3.5%. The dry degree of pure steam must not be less than 95%. The superheating value must not be higher than 25 °C. Simultaneously, engineers should regularly maintain the sterilizer.[17]	PubMed	Expert consensus	

(*Continued*)

Table 5 (Continued).

Themes of Evidence	Description of Evidence	Source	Type of Literature	Level of Evidence
Unloading and cooling stage	12. The cooling time of the sterilization package after sterilization is greater than or equal to 30 min, making it suitable for room temperature.[2,13,14]	NGC AORN CNKI	Guideline Guideline RCT	Level 2
	13. For cooling, keep away from the air conditioning outlet.[2,13]	NGC AORN	Guideline Guideline	Level 2
	14. In order to reduce the possibility of condensate formation, open the door slightly at the end of the cycle and leave the item inside for a while.[2–13,17]	NGC AORN PubMed	Guideline Guideline Expert consensus	Level 1
	15. Before cooling is complete, hot items should not be transferred from the cart to a cold metal rack or shelf for cooling.[2–13]	NGC AORN	Guideline Guideline	Level 1
	16. During cooling, avoid touching the sterile package with bare hands. Instead, using an infrared measuring instrument or temperature sensing device ensures that the sterilized items reach the specified temperature.[2,13,14]	NGC AORN CNKI	Guideline Guideline RCT	Level 1
Distribution stage	17. Regularly monitor the temperature and humidity of the sterile storage room, where temperature <24 °C, and humidity < 70%.[2]	NGC	Guideline	Level 1
Wet pack evaluation and analysis	18. The staff used the wet pack evaluation checklist and the wet pack evaluation flow chart to analyze the causes of the wet pack and keep records.[2,14]	NGC CNKI	Guideline RCT	Level 1
	19. The staff used a multidisciplinary team to investigate the causes of the wet pack and kept records.[2,17]	NGC PubMed	Guideline Expert consensus	Level 1
Personnel training	20. Every year after a new entry, sterilization personnel should be trained and recorded.[12]	PubMed	Guideline	Level 2

Abbreviations: AORN, Association of Operating Room Nurses; AAMI, Association for the Advancement of Medical Instrumentation.

significantly reduce the occurrence of wet packs.[11] The weight and volume of the sterilization package should be standardized in strict accordance with the standard requirements. In order to reduce the incidence of the wet pack, the weight of the instrument package should not exceed 7 kg, the weight of the dressing package should not exceed 5 kg, the sterilization volume of the pre-vacuum pressure steam sterilizer should not exceed 30 cm x 30 cm x 50 cm, and the sterilization volume of the lower exhaust pressure steam sterilizer should not exceed 30 cm x 30 cm x 25 cm. Therefore, it is suggested that the weight and volume of the sterilization package be strictly limited following the requirements of code in practical work and that oversized and overweight packages should be unpacked. Evidence 2 and 3 explain the methods for preventing wet packs from the standpoint of packaging materials. Researchers showed that the generation of the wet pack is closely related to the selection of packaging materials,[18] and using non-woven fabrics for double-layer instrument packaging is recommended. The inner layer of the dressing was cotton cloth, and the outer layer was non-woven cloth. Single-package instruments or smaller precision instruments should be packaged in paper-plastic packaging. At the same time, according to the packaging materials, choose the appropriate package of water-absorbent materials such as disposable water-absorbent paper and water absorbent pad. If there are many instruments, it is best to separate them with disposable absorbent paper, absorbent pad, or other absorbent material to avoid excess condensed water and a wet pack. Evidence 4 suggests that the device be disassembled to its smallest component and properly fixed before reassembling. If a U-frame is used, the steam contact area of the instrument can be increased to prevent the generation of excessive condensate. Finally, good quality control of packaging before sterilization is beneficial in reducing the risk of wet packing.

Correct Grasp of Sterile Package Sterilization Technology, Help to Reduce the Occurrence of Wet Bag

Loading Stage

Evidence 5–9 emphasizes the significance of standardized loading. Standardized sterilization loading can effectively avoid wet packs. When the items to be sterilized are loaded, it should be noted that they should be sterilized in the same batch to select the corresponding sterilization procedure better. In case of mixed loading, the textile items will be placed on the upper layer, and the equipment items will be placed on the lower layer to avoid the condensation water droplets

generated by the equipment items forming a wet pack on the sterilized items of the lower layer. When the special sterilization rack or sterilization basket is used to load the sterilized items, there is a 2.5 cm gap between the sterilization packs to allow steam to penetrate and the sterilization packs to dry. Paper packs, paper-plastic packaging items on the side, paper side down, can not be stacked together, and using an absorbent liner to evacuate condensates increases the evaporation area, and sterile packaging is easier to dry. The sterile package can not come into contact with the wall of the sterilizer, away from the bottom layer (exhaust port), the wall of the sterilizer has condensed water formation, sterile package contact with the wall of the chamber condensate will be immersed in the sterile package to increase the chance of the wet pack. A layer of cotton cloth on the sterilization rack to absorb water can prevent condensation water rack from dripping onto the sterile package of the lower layer and reduce wet pack formation. Surgical instrument packs and hard containers should be placed flat, basins, trays, and bowls oblique, and glass bottles and other utensils without holes in the bottom should be placed upside down or on the side. These placement methods are conducive to excluding condensed water and can effectively avoid the generation of the wet pack.

Sterilization Stage

Evidence 10 and 11 illustrate the influence of the operating parameters of the sterilizer on the wet pack. Sterilization parameters are the key factors leading to wet packs. It is suggested that the drying time of sterilization should be determined following the instructions provided by the manufacturer, and the drying time should be consistent with the actual sterilization time. Simultaneously, the occurrence of the wet pack is related to the depth of the sterilizer vacuum. Therefore, it is suggested that in practical work, the CPSU staff should be aware of the key parameters and ranges in the sterilization process, such as the number of pulses in the preparation stage, sterilization temperature, sterilization time, and drying time, steam injection rate and input pulse of filtered air in the drying stage, and pay attention to the quality of saturated steam. The proportion of non-condensable gas shall not exceed 3.5%, the dryness of pure steam shall not be less than 95%, and the superheating value shall not exceed 25 °C. At the same time, engineers regularly maintain the sterilizer.

Pay Attention to Device Unloading and Distribution, and Strictly Control the Incidence of Wet Package

Unloading and Cooling Stage

The unloading and cooling stages are critical links that affect the occurrence of the wet pack. Unloading time and cooling time are important reasons for the wet pack. Evidence 12 suggests allowing the sterilization package to cool for 30 min or more for the sterilization package after sterilization to make it suitable for room temperature. A cooling time of 30 min is recommended to be set within the disinfection supply center traceability system. If the set cooling time is not met, the system warns that the sterile package is unqualified and cannot be issued. Evidence 13 recommends keeping sterile packs away from vents and other locations where cold air is discharged during the cooling phase. Since there is still more heat and water vapor in the unloaded sterilization package, if it is not fully cooled and evaporated, condensation will form when the temperature difference is large, resulting in a wet pack. It has been reported that instrument packs with high density and heavy mass are easier to wet pack.[19] Evidence 14 and 15 recommend slightly opening the sterilizer cabinet door at the end of the sterilization cycle, leaving the sterile package for a while to reduce the possibility of condensation water formation, and not transferring the hot sterile package from the cart to a cold metal rack or shelf for cooling until cooling is complete. Evidence 16 indicates that using infrared measuring instruments or temperature sensing devices can verify whether the sterilized articles have reached the specified temperature. However, many hospitals do not have infrared measuring or temperature sensing devices in clinical practice for various reasons. Therefore, managers can focus on evaluating the operability of this evidence and prudently applying the evidence based on the hospital's actual situation.

Distribution Stage

Evidence 17 focuses on the effect of temperature and humidity on wet packs in sterile storage rooms. The wet pack also requires a sterile packaging storage environment. In practice, a temperature and humidity meter should be used to monitor the temperature and humidity in the sterile storage room. Head nurses and quality control personnel could examine whether the staff checked the temperature and humidity of the storage room and related records regularly and whether the supervision content and evidence differed.

Improve the Quality Management Plan, Improve the Early Warning Ability

Wet Pack Evaluation and Analysis

Evaluation and analysis of the wet pack is an important component of wet pack management and the key to continuous improvement. Evidence 18 suggests that staff use the wet pack evaluation checklist and the wet pack evaluation flow chart to analyze the causes of the wet pack and keep relevant records. Evidence 19 emphasizes that the cause of the wet pack should be analyzed and documented by a multidisciplinary team. Some studies have shown that steam pressure sterilization is a widespread issue involving multiple fields with complex influencing factors, where the CSSD team lacks a comprehensive grasp of knowledge. Therefore, implementing wet pack control has some flaws.[20] The multidisciplinary management team exemplifies integrity, system, and professionalism. Conversely, the central sterile supply department team dominates the management mode of a multidisciplinary team. The introduction of a multidisciplinary management team, refinement of key work content, clear division of labor, and more professional personnel are useful to complete the specialized medical work, ensuring the accuracy and effectiveness of the quality of sterile kits. Of course, the multidisciplinary team management model can specify the focus of attention at each stage and standardize the sterile package management from packaging to loading, sterilization, unloading, cooling, and distribution. This process is clear so that the team members understand the work content and ensure the continuity of management.[21] Finally, the purpose of improving management quality and reducing the wet pack incidence was achieved.

Personnel Training

Evidence 20 emphasizes the importance of personnel training in reducing the occurrence of the wet pack. It is suggested that sterilization personnel be trained and recorded on sterilization-related knowledge and operation skills when they are hired and thereafter every year. It has been reported that sterilization personnel plays a key role in the sterilization process. The quality, professional knowledge, and skills of sterilization personnel have a direct impact on the occurrence of the wet pack, which is closely related to the quality of sterilization and patient safety. Therefore, by strengthening training, personnel's awareness of wet pack management can be improved, and sterilization operation can be finally standardized to reduce the incidence of the wet pack.[22]

Conclusions

This study summarizes the best evidence for the prevention and management of the wet pack. The results from the present studies can provide a reference for clinical practice and suggest that practitioners carefully select and apply evidence based on work situations and the willingness of staff to ensure the safety of sterilization quality and reduce the incidence of wet packs. However, there are some limitations to this study. The literature included in this study was limited to Chinese and English, which may lead to the omission of some high-quality original research results. It is suggested that future researchers broaden the scope of their literature search and thoroughly explore the best evidence for the prevention and management of the wet pack to better guide clinical practice.

Data Sharing Statement

The datasets generated and analysed during the current study are not publicly available due raw data is part of intellectual property, but are available from the corresponding author on reasonable request.

Ethics Approval and Consent to Participate

This study was not related to experiments on humans and/or the use of human tissue samples. The need for ethics approval and informed consent was waived by the institutional review board of West China Second University Hospital. All methods were carried out in accordance with relevant guidelines and regulations.

Author Contributions

All authors made a significant contribution to the work reported, whether that is in the conception, study design, execution, acquisition of data, analysis and interpretation, or in all these areas; took part in drafting, revising or critically reviewing the article; gave final approval of the version to be published; have agreed on the journal to which the article has been submitted; and agree to be accountable for all aspects of the work.

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Disclosure

The authors declare that they have no competing interests for this work.

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