



Acta Paulista de Enfermagem

ISSN: 0103-2100

ISSN: 1982-0194

Escola Paulista de Enfermagem, Universidade Federal de São Paulo

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Acta Paulista de Enfermagem, vol. 32, núm. 1, Janeiro-Fevereiro, 2019, pp. 101-105

Escola Paulista de Enfermagem, Universidade Federal de São Paulo

DOI: 10.1590/1982-0194201900014

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Wet packs: Is extending drying time increasing water (scarce natural resource) consumption?

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Paquetes mojados: el aumento del tiempo de secado aumenta el consumo de agua (recurso natural escaso)?

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Keywords

Steam; Sterilization; Water consumption; Natural resources; Equipment and supplies

Descritores

Vapor; Esterilização; Ingestão de líquidos; Recursos naturais; Equipamentos e provisões

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Vapor; Esterilización; Ingestión de líquidos; Recursos naturales; Equipos y suministros

Submitted

November 10, 2018

Accepted

February 7, 2019

Abstract

Objective: This study aims to compare water and power consumption in four cycle configurations (number of pulses in the conditioning phase, drying time, and vacuum depth set point) for steam sterilization.

Methods: A descriptive study of four different cycle configurations: In configuration A, conditioning phase vacuum pulses were set to a total of three, with a lower vacuum set point of 90 mbar and a higher pressure set point of 1500 mbar. The drying phase was set for 45 minutes with a vacuum level of 90 mbar. Water and power consumption were measured during the entire conditioning phase, and every 15 minutes during the drying phase. In configuration B the conditioning phase vacuum set point was adjusted to 150 mbar and the other parameters were identical to configuration A. On configurations C and D, the quantity of vacuum pulses was set to five, with higher pressure adjusted to 1500 mbar in both configurations. The lower vacuum set point was adjusted to 90 mbar in configuration C and to 150 mbar in configuration D.

Results: Water consumption at the drying phase had the most impact on the total water consumption for the entire cycle.

Conclusion: This study shows that increasing drying time to solve wet packs will increase water consumption, a scarce natural resource, and should be the last option to achieve dry loads at the end of the cycle.

Resumo

Objetivo: Este estudo tem como objetivo comparar o consumo de água e energia em quatro configurações do ciclo (número de pulsos na fase de condicionamento, tempo de secagem e valor de ajuste da profundidade do vácuo) para esterilização a vapor.

Métodos: Estudo descritivo de quatro diferentes configurações de ciclo: na configuração A, os pulsos de vácuo da fase de condicionamento foram ajustados no total de três, com a profundidade de vácuo em 90 mbar e o ponto positivo de pressão em 1500 mbar. A fase de secagem foi ajustada em 45 minutos com a profundidade de vácuo em 90 mbar. Os consumos de água e energia foram medidos durante toda a fase de condicionamento e a cada 15 minutos durante a fase de secagem. Na configuração B, a profundidade de vácuo na fase de condicionamento foi de 150 mbar e os outros parâmetros foram idênticos aos da configuração A. Nas configurações C e D, o número de pulsos de vácuo foi ajustado no total de cinco, com o ponto positivo de pressão em 1500 mbar nas duas configurações e a profundidade de vácuo de 90 mbar e 150 mbar, respectivamente.

Resultados: A água consumida durante a fase de secagem teve grande impacto sobre o consumo total de água durante todo o ciclo.

Conclusão: Este estudo evidenciou que o aumento do tempo de secagem para solucionar pacotes molhados aumenta o consumo de água, um recurso natural escasso, que deve ser utilizado como última opção para obter pacotes secos ao fim do ciclo.

Resumen

Objetivo: Este estudio tiene el objetivo de comparar el consumo de agua y energía en cuatro configuraciones del ciclo (número de pulsos en la fase de acondicionamiento, tiempo de secado y valor de ajuste de la profundidad del vacío) para esterilización a vapor.

Métodos: Estudio descriptivo de cuatro diferentes configuraciones de ciclo: en la configuración A, los pulsos de vacío de la fase de acondicionamiento se ajustaron en el total de tres, con la profundidad de vacío en 90 mbar y el punto positivo de presión en 1500 mbar. La fase de secado se ajustó en 45 minutos con la profundidad de vacío en 90 mbar. Los consumos de agua y energía fueron medidos durante toda la fase de acondicionamiento y cada 15 minutos durante la fase de secado. En la configuración B, la profundidad de vacío en la fase de acondicionamiento fue de 150 mbar y los otros parámetros fueron idénticos a los de la configuración A. En las configuraciones C y D, el número de pulsos de vacío se ajustó en el total de cinco, con el punto positivo de presión en 1500 mbar en las dos configuraciones y la profundidad de vacío de 90 mbar y 150 mbar, respectivamente.

Resultados: El agua consumida durante la fase de secado tuvo un gran impacto en el consumo total de agua durante todo el ciclo.

Conclusión: Este estudio evidenció que el aumento del tiempo de secado para solucionar paquetes mojados aumenta el consumo de agua, un recurso natural escaso, que debe ser utilizado como última opción para obtener paquetes secos al final del ciclo.

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DOI

http://dx.doi.org/10.1590/1982-0194201900014



How to cite:

Laranjeira PR, Bronzatti JA, Souza RQ, Graziano KU. Wet packs: Is extending drying time increasing water (scarce natural resource) consumption? Acta Paul Enferm. 2019;32(1):101-5.

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Conflicts of interest: none to declare.

Introduction

The basic principle of sterilization by steam is to allow each product to be exposed to steam at a pre-determined temperature, time, and pressure.⁽¹⁾ The cycles vary according to the process; however, they can be summarized in three phases: conditioning, exposure, and drying.

The process requires water for the generation of steam and for the operation of the vacuum pump or Venturi system used for air removal in conditioning phase and to exhaust steam in the drying phase. For the equipment with a vacuum pump, the water consumption per cycle is estimated in 150 – 600 L, according to the model, brand, and size of the autoclave. Autoclaves that use the Venturi system to generate vacuum, which internal chamber size does not exceed 250 L, can consume up to 700 L of water per cycle.⁽²⁾

If visible moisture is present inside or outside a package after sterilization and proper cooling period, the package is considered a wet pack and investigations must be conducted to discover and diagnose the problem.⁽³⁾ Unfortunately, this is a common issue in Sterile Processing Departments (SPD) in every continent.

Wet packs often lead to waste of time and effort, increasing the work load, costs (ie: sterile barrier, chemical indicators, etc) and delay or cancellation of surgical procedures.⁽⁴⁾ In addition, the loads are potentially contaminated, increasing the infection risk for the patient.⁽⁴⁾

Drying time is pointed as one the problems, and since it is an easy solution, many SPD professionals and maintenance teams increase randomly it's time, and because sterilizer jacket is kept pressurized, where temperature transfer helps drying the load, a false solution is attained.^(5,6) Since drying phase occurs with the equipment in vacuum, normally a water sealed vacuum pump is used, and by increasing the time in this stage, there also will be an increase in water consumption. One over seen solution is to increase the vacuum depth,⁽⁷⁾ which causes condensate to evaporate in a lower temperature. Another approach in finding a solution for wet packs is to increase the vacuum depth and number of vacuum pulses at the conditioning phase.

This study aims to compare water and power consumption in four cycle configurations (number of pulses in the conditioning phase, drying time, and vacuum depth set point) for steam sterilization.

Methods

An experimental descriptive study of four different cycle configurations: In configuration A, conditioning phase vacuum pulses were set to a total of three, with a lower vacuum set point of 90 mbar and a higher pressure set point of 1500 mbar. The drying phase was set for 45 minutes with a vacuum level of 90 mbar. Water and power consumption were measured during the entire conditioning phase, and every 15 minutes during the drying phase. In configuration B the conditioning phase vacuum set point was adjusted to 150 mbar and the other parameters were identical to configuration A. On configurations C and D, the quantity of vacuum pulses was set to five, with higher pressure adjusted to 1500 mbar in both configurations. The lower vacuum set point was adjusted to 90 mbar in configuration C and to 150 mbar in configuration D. Cycles A, B, C, and D were used to compare the conditioning phase different configurations results and drying phase results were only compared on cycles A and B, because cycles C and D had the same drying configuration respectively. This study was conducted at the CISA Brasile™ sterilizer manufacturing plant, located in Joinville, Santa Catarina, Brazil in August, 2016. A 600 liters CISA steam sterilizer, model 6410, using a water sealed pump, with an inlet water temperature between 19°C and 23°C. One hygrometer was installed at the water pump inlet and another at the steam generator water inlet. Equipment power consumption was measured with a wattmeter. Sterilization cycle conditioning and drying phases and the exposure phase was kept at 134°C per three minutes, in all cycles. All cycles were monitored with physical indicators printed by the equipment: time, temperature and pressure. Their accuracy was demonstrated in the equipment qualification report. The article does not have research involving human beings, it is not necessary to send a copy of the approval by an Ethics Committee recognized by

the National Research Ethics Committee (CONEP), according to the norms of Resolution 466 / 2012 of the National Health Council - CNS or equivalent body in the country of origin of the research.

Results

On the conditioning phase, deeper vacuum levels and more vacuum pulses increases the efficiency of air removal and condensate evaporation, reducing drying time and water consumption. By making the vacuum level deeper, from 150 mbar to 90 mbar, water consumption was increased by 55%, and by adding two additional vacuum pulses, from three to five, a 45% increase was observed. In this last situation, water consumption for the steam generator was slightly increased, along with power consump-

tion, due to the necessity of generating more steam for the two additional pulses (Figure 1).

Water consumption at the drying phase had the most impact on the total water consumption for the entire cycle. For each additional minute in the drying phase, an approximate ten-liter increase in water consumption was observed, representing a 100% increase in water consumption in the dry phase for each 15-minute additional drying time (Figure 2). By reducing the vacuum level from 150 mbar to 90 mbar, which improves evaporation effect, water consumption was only increased by five percent, in the first 15 minutes, because after the vacuum level is reached, the consumption of water is just to maintain the vacuum level. Water, for the steam generator, and power consumption had discrete increase for each 15-minute additional drying time.

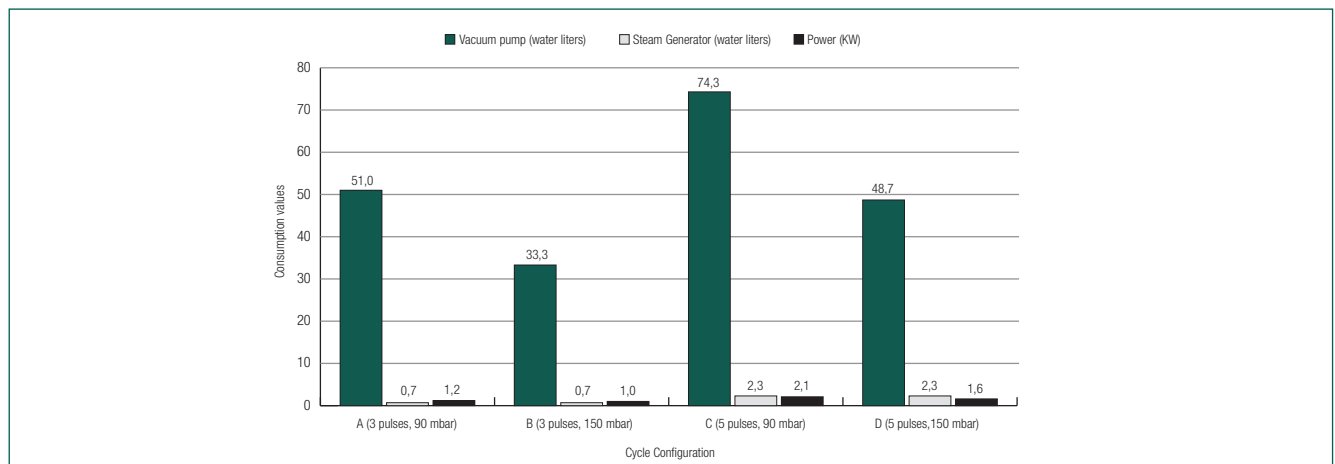


Figure 1. Average water and power consumption during the conditioning phase for each cycle configuration

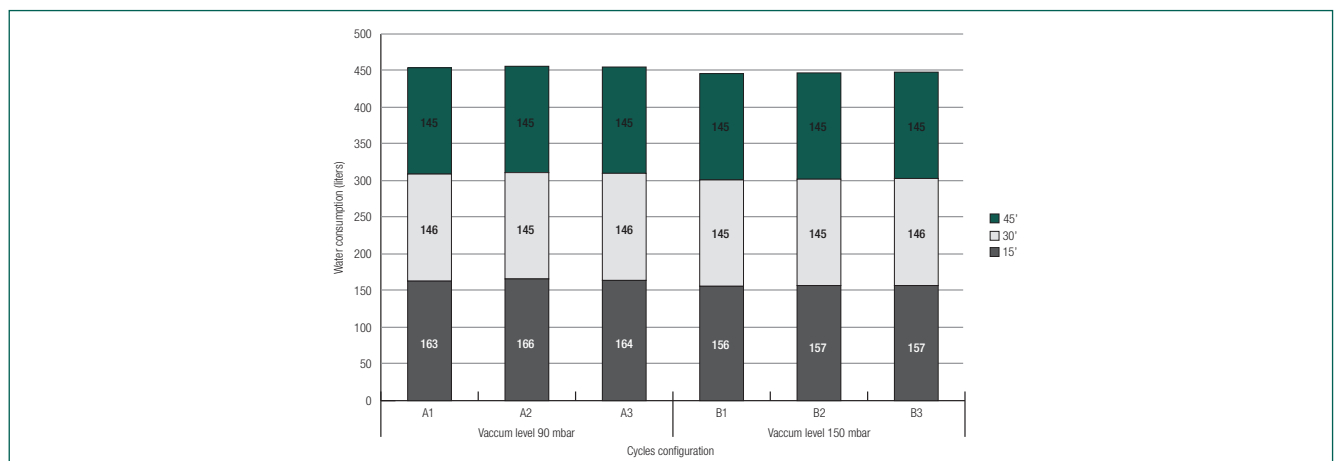


Figure 2. Triplicate results for configurations A and B of total water consumption during drying phase, for each cycle, in 15 minutes' intervals

Discussion

SPD nurses are continuously faced with a dilemma when a wet pack is identified after a sterilization cycle, generating insecurity for the surgical team and consequently for the patient. AAMI ST79 indicates that wet packs are to be considered contaminated and must be reprocessed.⁽³⁾ But there are studies that have shown no evidence on contamination inside packs that were wet.^(8,9) Unfortunately, this conflicting positioning between standards and research haven't yet created a decisive definition on how to handle wet packs. Another observation is regarding biological, chemical and physical indicators results. It is well known that these indicators are used to help SPD professionals determine if sterilized medical devices can be safely released and even if all the indicators shows satisfactory results, the load cannot be cleared if there is presence of moisture or water at the end of the cycle.⁽³⁾ Solutions to solve wet packs must consider indirect impacts, like the increase of water consumption, a natural resource in scarcity, caused by extending the dry time of the cycle. Also, actions should focus on steam sterilization principles, where the conditioning phase plays an important role in load conditioning, and by increasing the vacuum set point will improve condensate evaporation during this phase, and by taking the same action at the drying phase, it will also improve condensate evaporation, and both actions are adequate solutions for wet packs problems. If the only option to solve wet packs is to increase the drying time, an investment in vacuum pumps that do not use water or a computerized recirculating water system, which controls volume, temperature and quality, should be implemented to reduce water consumption.

Conclusion

The most efficient cycle configuration is to set the vacuum point to 90 mbar at the conditioning and drying phase, which in reduce the evaporation water temperature, demanding less time in the drying phase. Reducing the vacuum point to 90 mbar will demand

more running time of the vacuum pump, increasing the water consumption at that moment, but it will compensate in the time reduction at the drying phase, were water consumption has the most impact. Sterilization equipment performance and consumption varies between brand, size, and models, but this study shows that increasing drying time will increase considerably water consumption and should be considered the last resource to solve wet packs. One solution to solve wet packs is to adjust the vacuum set points to lower values, in the conditioning and drying phase.

Acknowledgments

This study was financed in part by the Coordenação de Aperfeiçoamento de Pessoal de Nível Superior - Brasil (CAPES) - Finance Code 001.

Collaborations

Laranjeira PR, Bronzatti JAG, Souza RQ and Graziano KU contributed with project and interpretation of data, writing of the article, critical review of the intellectual content and final approval of the version to be published.

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