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Literature Review of Staff Thermal Comfort and Patient "Thermal Risks" in Operating Rooms

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Summary: *This paper discusses the thermal comfort of Staff and the "thermal risks" for the patient in operating rooms. Staff has often reported thermal discomfort during surgery. Factors which affect the thermal comfort include physiological and psychological perception, climate, the level and type of physical activity, and the types of clothes worn. Evaluating the "thermal risks" of the patient is very important in order to know how to prevent him/her from suffering hypothermia. The results will show that there is a strong need for future research and also which areas need to be focused on.*

Keywords: *thermal comfort, preventing hypothermia, operating room.*

1. Introduction

A person produces thermal energy through the oxidation of glucose from what they have consumed. This process is named Metabolism. A great part of this energy (80%) is used for the maintenance of the body, while 20% is expended in work. Oxidation can increase in some situations, for example, with increased activity level or increased body temperature. Indoors, the temperature of the human body remains constant. The normal temperature is about 37ºC (36.1~37.2ºC). Outside these limits a person is considered to be sick, however, they can survive at a minimum temperature of 32ºC and at a maximum of 42ºC [1].

Heat transfers between the person and the environment. The body uses thermo-regulatory mechanisms to compensate the gain or loss of heat to keep body temperature in equilibrium. This system is known as the hypothalamic thermostat, which "tells" the body to increase or decrease the temperature, in accordance with thermal needs. A person is in thermal comfort when he/she is satisfied with the thermal environment [2 and 3] and does not need to use their thermo-regulator mechanism. Factors which affect the thermal comfort include physiological perception, climate, the level and type of physical activity, and the types of clothes used.

This paper reviews the thermal comfort of the Staff, and the "thermal risks" for the patient in Operating Rooms (ORs). Some Staffs have reported thermal discomfort during surgery. Understanding and managing the thermal comfort in Operating Rooms (ORs) is complex because each person has different needs and can present different thermal sensations. Thermal comfort in relation to environmental factors depends on environment temperature, radiant temperature, relative humidity, air velocity, level and type of activity, metabolic rates, and clothing [2]. In operating rooms these variables can change in accordance with the type of surgery, because each surgery can present different patient requirements, different levels and types of activities of the Staff, different types and numbers of equipment and lights, different numbers of people, and sometimes the type of surgery and the function of the person in the OR also define the clothes.

The issue of the "thermal risks" of the patient is more difficult to resolve, because the patient is anesthetized and, therefore, his/her thermo-regulatory mechanisms are not in action. In addition, sometimes the type of surgery does not permit heating through coverlets or other systems. The patient's temperature must be controlled to prevent it, for example, from dropping enough to cause Perioperative Hypothermia, which could lead to a higher chance of PIR and other risks [4]. Some researchers rated low ambient operating room a critical risk factor for hypothermia [5].

Managing the thermal discomfort of the Staff is also complex, because it is usually not possible to reduce the amount of clothing, to alter the activity being performed, or to reduce the various heat sources used during the surgery. Sometimes the Staff must use alternative types of protection that can change their thermal sensation, for example, when additional special clothing or a Helmet Aspirator System is used.

The purpose of this paper is to discuss the points described above more in detail, and also to explore the following questions:

a) Is the "thermal protection" for the patient or the thermal comfort of the Staff prioritized?

b) Is it possible to optimize the thermal comfort for the Staff, and at the same time to ensure an adequate environment temperature for the patient, while preventing hypothermia?

c) What are the alternatives used to prevent the hypothermia and to improve the thermal comfort for the Staff in OR?

d) What is the influence of the heating system used for the patient on the thermal comfort of the Staff?

e) What are the thermal comfort results of different types of ventilation systems?

f) What thermal comfort does the Staff and what the "thermal risks" do the patient experience in different types of surgery?

This will be done by conducting a literature review. The results of this exploratory review clearly show that there is a need for future research. The paper also indicates which research areas require particular focus. The rest of the paper is organized as follows: The next section addresses each question in turn, and the section that follows offers conclusions and recommendations for future work.

2. Results and Discussion

2.1. Is the "thermal protection" for the patient or the thermal comfort of the Staff prioritized?

In operating rooms the thermal environment for the patient is prioritized over the Staff. However, it is also important to ensure adequate conditions for the Staff, permitting good quality of work and thermal sensation. There is much research which shows the link between the thermal comfort of workers and their level of productivity and the quality of work. In operating rooms, of course, the workers are the Staff. However, none study was found reporting this relationship.

2.2. Is it possible to optimize the thermal comfort for the Staff, and at the same time to ensure an adequate environment temperature for the patient, while preventing hypothermia?

It is impossible to specify a thermal environment that will satisfy everybody. There will always be a percentage of occupants who perceive thermal discomfort; however, sometimes it is possible to optimize the thermal conditions for the Staff and patient. [3]

2.3. What are the alternatives used to prevent the hypothermia and to improve the thermal comfort for the Staff in OR?

One way to prevent hypothermia in the patient is to have a high ambient temperature in the OR. [6]. A temperature between 24ºC and 26ºC is suitable, while temperatures below 21ºC put the patient at risk of becoming hypothermic [7]. However, a temperature > 23ºC is usually intolerable for the surgical Staff [4 and 6].

Another alternative to prevent hypothermia is to use cutaneous warming, one of the various passive and active warming devices. Active warming devices as more effective than passive coverings at transferring heat, and they can, over time, reverse hypothermia that has developed due the redistribution [4]. It was reported the devices are more efficient when positioned above the patient, rather than underneath, because little heat is lost from the back to the operating table. However, these warming devices used on the operating table are very useful in solving the problem when the surgery is highly invasive and it is not possible to use other types of warming systems. Other practices applied during surgery are intravenous fluid warming and heating airway gases. Another recommendation to prevent hypothermia during the surgery is to use pre-warming systems, which are describe as the most effective means of maintaining normothermia [4]. Compared two warming systems (upper body force-air versus whole body water garment), the water warming system resulted in better maintenance of intraoperative nomorthermia [8].

To improve the thermal comfort in OR recommended a temperature between 20ºC and 22ºC for the Staff [7]. Olesen and Bovenzi recommended 23-24.5ºC for the anaesthesiologist, 22-24.5ºC for nurses, and 19ºC for the surgeon [9]. A temperature for the auxiliary nurse was not recommended, however, they would occupy the same zone as the surgeon.

Another alternatives discussed is the possibility to make good use of those type of ventilation systems which define three zones in the OR [9].

These types of ventilation systems allow the application of different temperature and air velocity in different zones. There are some types of ventilation systems which permit this use, including the laminar airflow combining the linear system, and some types of Plenum ventilation systems developed in The Netherlands. However, it is important to ensure that when using different temperature or air velocities, the airflow dynamic is not disturbed. This is very important because it ensuring the security of the patient and the instrument table should be priority in the OR (ideally, and whenever possible).

2.4. What is the influence of the heating used for the patient on the thermal comfort of the Staff?

Unfortunately, the heating systems, used to prevent the hypothermia in the patient, were not analysed in the literature in terms of the influence on the thermal comfort of the Staff. A definite area of future research then is to evaluate different systems and to asses how these systems have an influence on the Staff.

2.5. What are the thermal comfort results of different types of ventilation systems?

Different types of ventilation systems have different influence on the thermal comfort in OR. Designers seek to properly locate the supply outlets and extraction ports in the optimum locations to reduce the residence time of pollutants and enhance the energy utilization efficiency of the treated fresh air. The recommended ventilation system has to deliver air from the ceiling in a downward movement to several exhaust inlets located on opposite walls and barriers dividing the ceiling of the diffuser [10]. However, two other systems were considered acceptable, which supply the air directly over the patient. Other papers [9 and 11] considered the ventilation systems in their research, but they did not compare different systems, they only evaluated a specific type.

2.6. What thermal comfort does the Staff and what the “thermal risks” do the patient experience in different types of surgery?

Two papers [9 and 11] reported the thermal comfort for the Staff. Often the thermal sensation of the surgeon and nurse is hot, while the anaesthesiologist sometimes feels the thermal sensation of cold. The second paper compared two types of surgery, the Abdominal and the Orthopaedic. In the Orthopaedic surgery the surgeon and auxiliary nurse presented most discomfort, while the anaesthesiologists experience improved the thermal comfort. These papers also calculated the thermal comfort for the patient, based on Fanger’s PMV model which reported thermal sensation.

Another paper evaluated the thermal comfort in six types of surgery: orthopaedic, general, oto-laryngologic, obstetrics and gynaecology, pediatrics and urology surgeries. The results of the experiments showed the indices of the PMV and PPD exceeded the maximum value of +0.5 and 10%, every time the air temperature exceeded 24ºC, precisely in orthopaedics and urology. [12]

The surgical lights have significant influence in the thermal comfort of the Staff [8]. Some surgeries only use a surgical light, while others need two surgical lights or more, including the auxiliary surgical light. In surgeries the patient receives the general and major regional anaesthesias which disturb thermo-regulation [4].

The surgery will also define the position of the patient on the table, the warming systems used when necessary, and how much of the body will be exposed. The heat loss of the patient during the surgery is also directly related to these variables. The patient will lose heat through radiation (unclothed body), conduction (touch with the operating table and the air), convection (renewed air), and evaporation (skin and lungs).

3. Conclusion

At present there is very little research in this area, perhaps because in operating rooms the main concerns are to ensure good indoor air quality and to guard against infection control.

The literature review showed that there are important areas which still need to be focused on: the thermal comfort of the Staff and their level of productivity and quality of work; an assessment of how the different heating systems used to prevent hypothermia in the patient influence the Staff thermal comfort. Another area which merits further research is the alternatives to improve the thermal comfort of the Staff while at the same time preventing the onset of hypothermia in the patient. How could alternative uses of existing ventilation systems and the future use of proposed

ventilation systems improve thermal satisfaction levels in the OR? There is a strong need for future research to evaluate the Staff thermal comfort during different surgeries. This is very important, because different types of surgery require different types and level of activities, different type (and/or number) of surgical lights, different types and number of equipments, also different numbers of people, and patient's requirements in the OR. Some of these comments were also discussed before for some researchers [13, 14 and 15] which recommended additional studies in the thermal comfort of the Staff in the operating rooms, including analyses of the productivity.

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