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QUESTION 7: Does the use of ultraviolet (UV) light decontamination in the operating room (OR) reduce the risk of subsequent surgical site infections/periprosthetic joint infections (SSIs/PJIs) in patients undergoing orthopaedic procedures?

RECOMMENDATION: Yes, the use of UV lights during surgery are effective against airborne bacteria. However, due to the potential risks to the OR personnel, it is recommended that UV light only be used at unoccupied times for terminal cleaning of the room.

LEVEL OF EVIDENCE: Moderate

DELEGATE VOTE: Agree: 91%, Disagree: 4%, Abstain: 5% (Super Majority, Strong Consensus)

RATIONALE

The source of a large portion of the microorganisms responsible for PJIs are the airborne microorganisms in the OR [1]. The room traffic, door status and number of people in the room are the basic indicators of the quantity of airborne colony-forming units (CFUs) [2]. To reduce the number of airborne CFUs in the OR during surgery, techniques are applied such as surgical gowning with air outlets, the use of laminar airflow, a reduction in room traffic and the application of UV lights [2,4–7].

The efficacy of techniques designed to remove airborne bacteria from the OR is supported by current randomized controlled trials (RCTs) studies [1]. In the OR, a concentration of 10 m^{-3} or less airborne bacteria is defined as ultraclean air [2]. UV light at specific wavelengths breaks the molecular bonds in the DNA, thereby eliminating microorganisms that may cause subsequent infections. Since the first application, a relationship has been shown between different UV wavelengths and a decrease in infection rates with a reduction in CFUs or the obtaining of ultraclean air [3–5]. The first data related to the use of UV light during surgical procedures was from Duke University. With the use of UV light in all types of surgery in 1936, the infection rates and infection-related mortality rates decreased from 11.3 and 1.3% pre-1936 to 0.24 and 0% in 1960, respectively [6]. In a 1980 study, the rate of PJI following hip arthroplasty was reduced from 3.1 to 0.53% with the use of UV light [7].

In a randomized study of 30 hip arthroplasties performed by Carlsson in 1986, the use of UV lights in the OR were shown to significantly reduce the number of CFUs, both in the wound area and in the periphery of the room, as determined by volumetric air samples [8]. Another pioneering study in this field was conducted by the same team in 1989 [9]. The combined method of occlusive staff clothing and UV radiation was used and the air samples from 20 cases of hip arthroplasty were all reported as < 10CFU/m^3, which is the limit for “ultraclean air” (median 2.6, range 1.1 to 7.1).

In 1991, Berg et al. reported that UV lights were more effective than the ultraclean air enclosure method and applications of UV combined with occlusive clothing reduced infection [10]. Taylor et al. conducted a similar cohort study in 1995, in which different doses of UV lights were compared with laminar flow and conventional ventilation. Again, results favorable to UV lights were obtained [5]. Berg-Perier et al. compared the UV light method with the Charnley-Howorth ultraclean air enclosure in an economic, comfort and safety analysis and presented data that UV light was superior in respect to cost, comfort and safety when sufficient protection was provided [11].

One of the most important studies conducted was by Ritter et al. In their retrospective cohort study published in 2005, the infection rates of 5,980 joint arthroplasties were examined [12]. It was shown that the infection rate of 1.77% with the laminar flow before the application of UV light had decreased to 0.57% after the use of UV light without laminar flow ($p < 0.0001$).

Although several studies support the efficacy of the use of UV lights against airborne bacteria during orthopaedic surgical procedures, because of the potential side-effects on OR staff, this application has been restricted by the guidelines, and there are even recommendations that it should not be used [13,14].

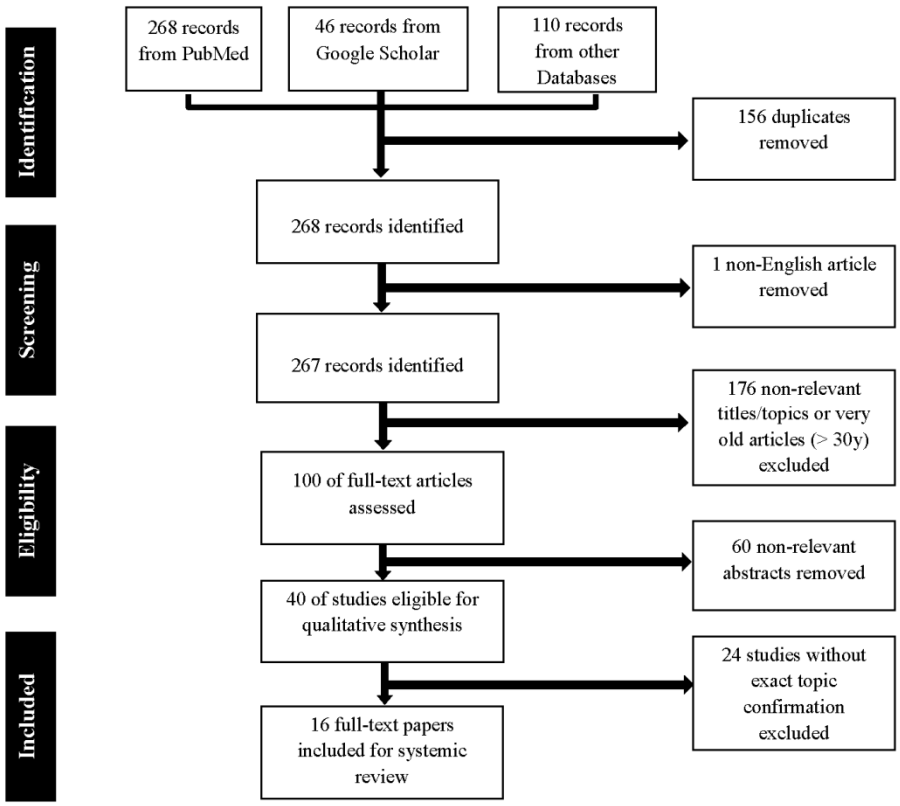

FIGURE 1. PRISMA Flowchart showing the identification of relevant studies during the review process.

There is no current data available related to the possible reduction of the use of UV lights during surgery in accordance with the guidelines and reported side-effects. New designs have been developed which could increase the safety of OR staff and provide maximum air disinfection effectiveness. However, there are no publications of the clinical efficacy of these new designs in respect to both of these aspects [15]. Possibly the most important area that could benefit from the germicidal effectiveness of UV light decontamination is terminal room cleaning of the OR or hospital rooms at unoccupied times.

The Tru-D (Tru-D Smart UVC, Memphis, Tennessee, USA) room disinfection device is a mobile, automated room disinfection device that uses UV-C irradiation to kill microorganisms. In an Mahida et al., the efficacy of the Tru-D device was evaluated in the terminal cleaning of patient rooms and the OR. It was reported that the mean $\log^{10}$ reductions for artificially seeded methicillin-resistant *Staphylococcus aureus* (MRSA) and vancomycin-resistant *enterococci* (VRE) were between three and four when used at 22,000 mWs/cm^2 reflected dose [16]. Similarly, through evaluation of logarithmic reductions, several studies have shown the effectiveness of UV devices in the inactivation of microbes seeded on various test surfaces placed in occupied hospital rooms [17–22]. Several clinical trials have also measured the effectiveness of UV devices in terminal room cleaning and have shown statistically significant reductions in the rates of healthcare-associated infections (HAIs) [23–26]. The only randomized, controlled study in this area, is a multi-center study by Anderson et al. that included nine hospitals. The terminal room cleaning method using the Tru-D device was utilized in two of four control groups formed of different combinations. The use of advanced room cleaning strategies, such as a UV device, was shown to reduce HAIs in every 10,000 cases from 51.3 to 33.9 ($p = 0.0369$) [27].

Furthermore, Fornwalt et al. reported on the efficacy of pulsed xenon ultraviolet lights on SSIs in patients undergoing total joint procedures in 2016 [28]. They found a significant reduction to zero infections after 12 months of surgery by renovating their orthopaedic surgery wing and by implementing new stringent procedures and pulsed xenon (PX)-UV decontamination before surgery.

Based on the overall evidence compiled (Fig. 1), despite the efficacy of UV light during surgery against airborne bacteria, its use is not justified due to the risks that could be created for operating room staff. However, evidence exists supporting the use of UV lights for the terminal cleaning of rooms at unoccupied times.

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