INFLUENCE OF STAFF BEHAVIOUR ON AIR QUALITY IN A CONVENTIONALLY-VENTILATED OPERATING THEATRE DURING A SIMULATED ARTHROPLASTY: A CASE STUDY AT THE UNIVERSITY HOSPITAL IN PARMA

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BACKGROUND

Surgical staff behaviour in the operating theatre (OT) is one of the factors associated with the indoor air quality and the risk of surgical site infections (Birgand et al, 2015).

PURPOSE AND HYPOTHESIS

The aim of this research was to assess the influence of staff behaviour on air quality in a conventionally-ventilated OT during two simulated hip arthroplasties performed under different surgical team behaviour use conditions.

MATERIALS AND METHODS

The study was performed in an operating theatre (OT) supplied with turbulent Heating Ventilation Air Conditioning (HVAC) system at the Orthopaedic Department of the University Hospital in Parma. The HVAC system was equipped with high-efficiency particulate air filters, with an efficiency of 99.97% for particles ≥0.3 µm and 15 air changes per hour. The first hip arthroplasty, was performed under "Correct use" (C) and corresponded to the operation performed with the surgical team behaving correctly, regarding in particular the number of people present in the OT, the door openings, the movements inside the OT and the surgical team talking. Simulation was developed considering real events such as surgical staff movements including general movement and three door openings during the surgical operation. The second hip arthroplasty was performed under "Not correct use" (NC), corresponded to the operation with the surgical team behaving not correctly. Fundamental disturbance factors were simulated such as sliding door opening/closing of the OT (25 times), ingoing and outgoing of circulating nurse and anesthetist and the talking and the walking around.
Moreover, experimental measurements were carried out also in "*at rest*" (R) condition before the simulated operations (Figure 1).
Bacterial and fungal contamination was evaluated by active (colony forming units per cubic metre, cfu/m³) and passive (Index of Microbial Air contamination, IMA) samplings (ISO 14698-1:2003, Pasquarella et al 2000) at three different points: operating table, intake grill and entrance door.
Airborne particles with diameter of ≥0.5 µm were counted on the operating table by a laser particle counter according to ISO 14644-1:2015.
Temperature, relative humidity and air velocity were measured respectively at the instrument table, at the intake grill and at the entrance door; mean radiant temperature and CO_2 were measured at the operating table. The data acquisition was made in transient condition over a time of second.

RESULTS

The highest levels of microbial and particle contamination were recorded during surgical operation with the surgical team not behaving correctly (NC), up to 93 cfu/m³, 16 IMA, 82696 P/m³ (≥0.5 µm) (Table 1); fungi were isolated at the operating table (1 cfu/m³ of *Penicillium* spp). Very low air microbial contamination was reached behaving correctly (C), with maximum values of 13 cfu/m³, 2 IMA, 64783 P/m³ (≥0.5 µm) and no fungal isolation.
Microclimatic parameter values are shown in Table 1 and Figure 2.

Figure 1. Operating theatre in at rest condition.

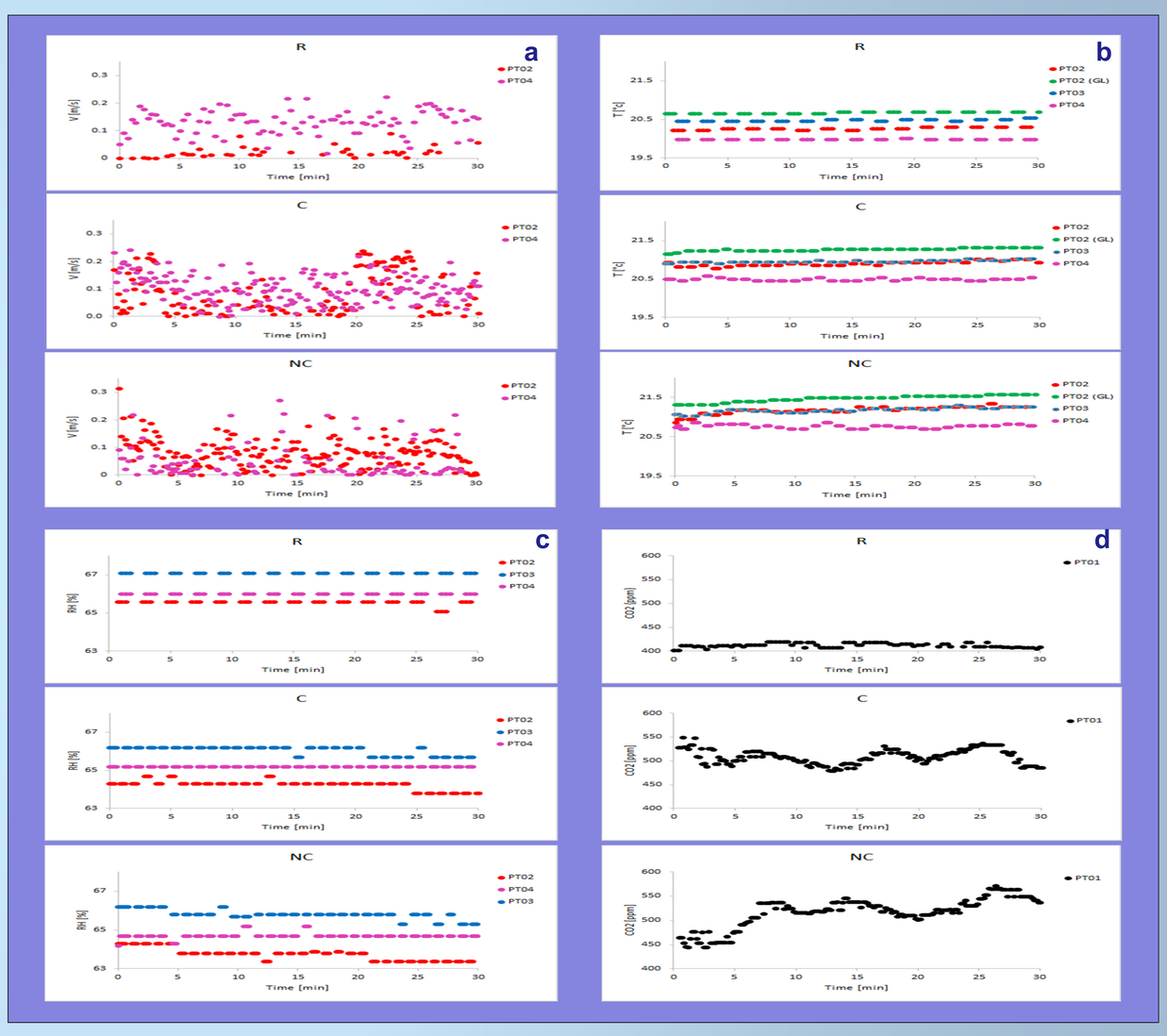

Figure 2 (a, b, c, d). Time series of the indoor air velocity (a), air temperature (b) air relative humidity (c) and CO_2 (d) concentration experimental values recorded in different conditions: (R), (C) and (NC) conditions. Temperature, relative humidity and air velocity were measured respectively at the instrument table (PT02) at the intake grill (PT03) and at the entrance door (PT04); mean radiant temperature and CO_2 were measured at the operating table (PT01).

Table 1. Bacterial air contamination values obtained with active (cfu/m3) and passive (IMA) sampling at different sampling point during at rest, correct and not-correct conditions

	Operating table			Intake grill			Entrance		
	R	C	NC	R	C	NC	R	C	NC
CFU/m³	2	13	74	3	23	44	4	29	93
IMA	0	2	8	0	6	8	2	4	16

R=*at rest*; C=Correct behaviour; NC=Not correct behaviour
CFU=Colony forming units; IMA=Index of microbial air contamination

Table 2. Microclimatic parameters at the indicated sampling points (average and range)

	R	C	NC
T (°C) - PT02	**20,27** 20,2-20,4	**20,91** (20,8-21,1)	**21,21** (20,9-21,5)
T radiant (°C) - PT02	**20,68** 20,65-20,74	**21,27** (21,15-21,32)	**21,50** (21,32-21,69)
Relative humidity (%) - PT02	**65,55** 65,1-65,6	**64,23** (63,8-64,7)	**63,71** (63,4-64,4)
Velocity (m/sec) - PT02	**0,011** 0,011-0,22	**0,056** (0,05-0,239)	**0,043** (0,085-0,301)
CO_2 (ppm) - PT01	**411,06** 399,2- 420,2	**507,72** (476,6-548,9)	**507,92** (445,1-572,1)

PT02 : instrument table), PT01 : operating table
R=at rest; C=Correct behaviour; NC=Not correct behaviour

CONCLUSIONS

Our study confirms that adherence to behavioural recommendations in OT is essential in order not to undermine the effectiveness of the Heating, Ventilation and Air Conditioning system. During (C) conditions very low biological contamination was detected both with active and passive sampling with results similar to those recommended for OT supplied with unidirectional HVAC system (10 cfu/m³, 2 IMA) (HTM 03-01, 2007; H+, 2007), while an increase in microbial contamination and modification of microclimatic parameters where observed while the surgical staff did not behave correctly (NC). Considering the operating conditions these parameter values are affected by the door opening/closing and surgical staff presence, especially their movements. This contribution appears particularly important considering the wider use of conventional operating theatres for hip arthroplasties, in the light of the debate still open regarding the unidirectional air flow ventilating system as a risk factor for surgical site infection in hip arthroplasties (WHO, 2016). Our study, including air biological, particle and microclimatic evaluation was performed, as a pilot study, in simulated arthroplasties; the transfer of this approach to real hip arthroplasties, with a wider collection of comparable data, will provide important knowledge on air quality in current conventional operating theatres also towards a definition of new updated threshold values.

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