Field investigation of thermal comfort level of patients and surgical staff in operating rooms at St. Olav's hospital

THE THERMAL COMFORT IN OPERATING ROOM IS CHALLENGING

Unsatisfactory thermal conditions in operating rooms (ORs) will influence the performance of surgical staff and increase the risk of developing surgical site infections (SSIs) possibility of patient. [1, 3] Therefore, there is essential to achieve the environment conditions where the highest possible percentage of the people will meet the thermal comfort. But by only revising the HVAC standard there is difficult to achieve thermal comfort for all occupants in operating rooms with clarified conditions [2]. Thus, there is necessary to investigate the area more to achieve the healthy environment for everyone.

OBJECTIVE

What is the thermal comfort level of four occupant group in operating room with LAF and dilution ventilation solution?

METHOD

1. Field measurements of indoor thermal environment
2. Observation of real surgical process for estimation
3. Survey – to collect direct thermal comfort feedback from surgical staff

Table 1 Clothing insulation and the activity level of occupants

<table>
<thead>
<tr>
<th>Occupant group</th>
<th>Clothing insulation, m²/K [cld]</th>
<th>Activity level, W/m² [met]</th>
</tr>
</thead>
<tbody>
<tr>
<td>Surgeon</td>
<td>0.202 (1.3)</td>
<td>138.3 (2.38)</td>
</tr>
<tr>
<td>Assistant nurse</td>
<td>0.154 (0.99)</td>
<td>74.8 (1.29)</td>
</tr>
<tr>
<td>Patient</td>
<td>0.165 (1.06)</td>
<td>68.4 (1.18)</td>
</tr>
<tr>
<td>Anesthetist</td>
<td>0.154 (0.99)</td>
<td>90.1 (1.55)</td>
</tr>
</tbody>
</table>

Focus on four occupant group:
- surgeon
- anesthetist
- assistant nurse
- patient

Environmental parameters:
- air temperature
- operative temperature
- mean radiant temperature
- air velocity
- air humidity

Individual parameters:
- activity level
- clothing

Figure 1. Mixing ventilation solution OR

- Area: 59.3 m²
- Type: Heart and emergency surgery
- RH = 12.1% - 39.2%
- \( v_c = 0.01 - 0.1 \) m/s

Figure 2. LAF ventilation solution OR

- Area: 56.1 m² (LAF area: 4x4m)
- Type: Orthopedic surgery
- RH = 17.1-44.7 %
- \( v_c = 0.02 - 0.36 \) m/s

Figure 3. The comparison between predicted and real thermal comfort in MV OR

Figure 4. Operational temperature in MV OR

Figure 5. The comparison between predicted and real thermal comfort in LAF OR

Material: polypropylene film and polyester/polyethylene nonwoven. Insulation in Table 1.

Surgical staff
- surgical undercap, hat, mask, socks, shoes and gloves (in MV OR also lead apron for x-ray)
- The surgeons will wear in addition to prior sterilized surgical gown.

Patient
- most of times naked and covered with warm blanket, surgical drape and polyethylene film (in MV OR forced-air warming blanket system).

St. Olav’s hospitals two ORs with LAF and mixing ventilation solution

The operative temperature near anesthetist and assistant nurse is higher, activity level lower and thermal sensation is neutral. Due to low operative temperature and air velocity, the patient will feel uncomfortable.

SUMMARY

1. Surgeons thermal sensation is warm.
2. Assistant nurse feels in MV OR warm and in LAF OR neutral.
3. Anesthetist experiences thermal comfort in both OR.
4. In MV OR are more occupants, who are dissatisfied with thermal environment than in LAF OR.
5. In LAF OR, the air temperature is lower and velocity is higher => the thermal comfort of patient is disturbed.

RESULTS

Overall thermal comfort in MV OR

Occupants in real operations, are more dissatisfied than can estimate from theoretical calculations (Figure 3). Actual sensation is warmer - surgeon and assistant nurse have high activity level (Table 1) and operative temperature (Figure 4).

The operative temperature and activity level of anesthetist is lower. The predicted sensation of patient will be in the boundary of thermal comfort, but the real sensation will be slightly cool.

Overall thermal comfort in LAF OR

In real operation the occupants will feel more comfortable, than the PMV calculations show (Figure 5). However, the measurements show lower operative temperature (Figure 6) and higher air velocity than usual, then due to higher activity, the thermal sensation of surgeon is warm.

SUGGESTIONS:

1. Investigate, how to reduce the thermal impact of surgical light
2. Investigate, how much it is possible to raise the air change rate in dilution ventilated OR to take out the heat gain produced by equipment
3. Focus on the clothing in OR to achieve the environment conditions where the highest possible percentage of the people will meet the thermal comfort

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Abbreviations:
- OR – operating room;
- MV – mixing ventilation;
- LAF – laminar air flow;
- ±0.5 cold; ±1.0 cold; ±1.5 slightly cold; ±0.5 neutral; ±1.0 slightly warm; ±2.0 warm; ±3.0 hot

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