IMPROVING LAMINAR FLOW EFFICIENCY IN THEATRES, ORTHOPAEDIC THEATRES

TEAM MEMBERS:

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Background:

Laminar flow ventilation systems provide exponential flow of ultra clean air to reduce airborne microbial contamination and subsequent surgical site infection (SSI). Much of the evidence for laminar flow use is based in orthopaedic surgery, especially in relation to prosthetic implantation[1]. This has led to both NICE and BOA advocating for its use in major implant and arthroplasty surgery. However, there is little evidence for the use of laminar flow in other operative indications or surgical specialities[2]. Estimates of the laminar flow use at GHNFT suggests it accounts for up to 30-60% of the overall energy output of our theatres. Consequently, inefficient, and unnecessary use of laminar flow ventilation system can lead to significant cost and environmental implications.

Specific Aims:

1) Determine the baseline use of laminar flow in emergency theatres
2) Develop strategies to improve laminar flow efficiency

Methods and measurement:

The first part of the project involved identifying the baseline use of laminar flow in orthopaedic and emergency theatres. This was done by involving the theatre staff and determine how the laminar flow is used at GHNFT. Currently, the system is on full power from the beginning of the theatre list till the end in both emergency and orthopaedic theatres. The nature of the emergency theatre means that it has variable start and end times making it difficult to pinpoint the exact usage each day. However, what is clear is that whenever the theatre is in use the laminar flow ventilation is on full power.

To estimate the current laminar flow use details of all the operations performed in August 2022 were reviewed. Each case was assessed to see if laminar flow was clinically indicated. The guideline for laminar flow use was provided by the British Orthopaedic Association who advise that any case involving use of an implant should consider the using laminar flow ventilation. The overall times of the operations were then added together to provide an estimate of the overall unnecessary use of laminar flow in emergency theatres.

Economic analysis

Details on the overall energy output (Kw/h) of the laminar flow system in both orthopaedic and emergency theatres was sought from our estates team. This involved identifying the kWh of each of the four fans used in the theatres. This was found to be a total of 6.2 kWh. The cost per kWh of electricity was then provided by the trusts energy manager (Tatiana Iona). An upper and lower estimate of the costs was provided due to the varying energy pricing and complexities of the way the trust manages its energy. Calculating the cost (£) of unnecessary laminar flow was done using following equation:

Excess Laminar flow use (kWh) X £0.17-£0.27 (Cost (£) per kWh)

Environmental analysis

The carbon footprint of the unnecessary laminar flow use was calculated using the emission factor for electricity provided by the energy manager at our trust (Tatiana Iona). Due to the way the trust uses its energy this number is different to the emissions factor used nationally. Again, an upper and lower estimate was provided. The trust emission factor for electricity was then multiplied by the total kWh of the unnecessary Laminar flow use to provide a total carbon emission.

Excess Laminar flow use (kWh) X 0.211-0.386 kgCO2e/kWh (carbon emissions factor)

Social sustainability:

Decibel measurement of full power laminar flow using a decibel meter app called “decibel X”

Solution for Emergency Theatre

As almost no orthopaedic operation happens in the emergency theatre our plan was to switch laminar flow off entirely. A standard operating procedure (SOP) has been created for this. This was disseminated across the surgical division.

Solution for Orthopaedic Theatres

The need for laminar flow is discussed at the morning surgical safety brief. The laminar flow is only switched off if there are no more cases that would require laminar flow in those days operating session. E.g. if a non-laminar flow case was sandwiched between two laminar flow cases then the laminar flow would remain on for all cases. This ensures that the laminar flow remains on when it is required and reduce labour for the theatre staff. A traffic light system to help clinicians determine which cases were appropriate for laminar flow was also created. This is shown in Appendix 1.

Results:

Baseline data:

Our audit has highlighted that only 2 of the 180 cases performed in emergency theatres in August required laminar flow ventilation. This resulted in just over 305 hours of unnecessary laminar flow use. Whilst in orthopaedic theatres around 20% of cases did not require laminar flow amounting to a total of 206 hours of wasted laminar flow use. The average laminar flow energy consumption is 6.2kWh. Consequently around 3168.2 kWHhare wasted per month. It is important to recognise that this figure

represents an underestimation as we have only accounted for operation time. We have not included any of the down time between cases when the laminar flow remains at full power.

Patient outcomes:

Evidence suggests that laminar flow is potentially harmful in non-orthopaedic operations[2]. This may be related to a variety of factors such as dehydrating soft tissues and improper use leading to incorrect airflow. As the emergency theatre is almost exclusively used for non-orthopaedic operations, we anticipate improved patient outcomes in SSI and wound complications. However, we have not formally assessed this in this project.

Environmental sustainability:

Our carbon footprint calculations suggest that between 0.6-1.2 Tonnes of CO2e are wasted by our current laminar flow use in emergency and orthopaedic theatres per month. Annually we project that this accounts for between **8 -14.7 Tonnes CO2e per year** (average saving of 11,350 kgCO2e), equivalent to driving 23,041 – 42,339 miles driven in an average car.

Economic sustainability:

Our economic analysis suggests that between £538.9 and £855.41 can be saved each month by improving laminar flow efficiency in theatres. This projects to annual savings of £6,463.13 to £10,264.97 (average saving of £8,364.05.

Social sustainability:

As the laminar flow involves four powerful fans it understandably creates quite a lot of noise. Using our decibel meter this equates to 60 decibels. By switching the laminar flow off this will create a better theatre environment allowing for easier communication between staff. This has benefits in improved concentration, staff wellbeing, and training.

Discussion:

Laminar flow ventilation is commonplace in many modern theatres in the UK. By using power meters in theatre, ours estimates locally suggest it accounts for around 42% of the total energy output of the operating theatres (Total standby energy consumption of theatres is 14.7kWh). It is therefore critically important to have an efficient control of these specialised ventilation systems in theatre. This project has highlighted that the awareness of how much energy the laminar flow uses, and its clinical indications is poor. This has led to excessive use. This was especially evidenced by the use in the emergency theatres at our trust. The COVID pandemic has likely exacerbated this as one of the benefits of the laminar flow system is that it produces 450-500 air changes per hour thereby cleaning contaminated air much faster. This has led to an increase in its use. It is important for other trusts to consider if increased laminar flow use is still necessary now the peak of the COVID pandemic has ended.

Most modern laminar flow systems offer a simple method of controlling the power of the laminar flow systems. Laminar flow has a patient safety, environmental and cost impact. By introducing its use into the theatre list briefing it allows its use to be discussed and rationalised to reduce excessive use. Other

considerations are to use automatic controls e.g., the laminar flow system being paired to theatre lights or motion sensors. This would provide potentially the most efficient system but does require the greatest cost to implement. Additionally, this may not be possible in older theatre ventilation systems.

Conclusions:

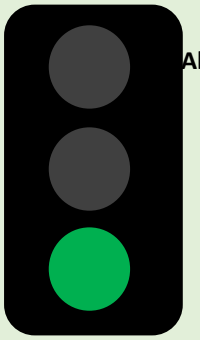
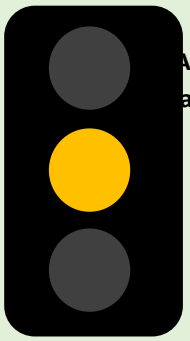
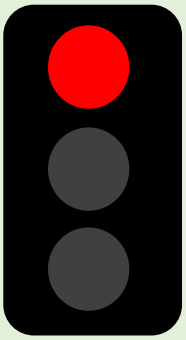
Laminar flow ventilation is often misunderstood and underappreciated factor in the energy consumption of theatres. Raising awareness to its use can help surgical teams make more informed decisions on if it is required for a case. Using theatre briefings or checklists offers a simple solution however, using automatic controls should also be considered as a longer-term solution particularly in newer theatres. Ventilation and theatre environment plays a role in surgical site infections. As a result, it is important that the complete clinical governance is done should this be introduced at your trust. Starting this early will help identify any stumbling blocks that may occur. This is particularly the case in older theatres where the systems may not work efficiently enough to allow changes to theatre ventilation schedules.

References:

1. Lidwell OM, Elson RA, Lowbury EJL, et al. Ultraclean air and antibiotics for prevention of postoperative infection: A multicenter study of 8,052 joint replacement operations. *Acta Orthop*. 1987;58(1):4-13. doi:10.3109/17453678709146334
2. Bischoff P, Kubilay NZ, Allegranzi B, Egger M, Gastmeier P. Effect of laminar airflow ventilation o n surgical site infections: a systematic review and meta-analysis. *Lancet Infect Dis*. 2017;17(5):553-561. doi:10.1016/S1473-3099(17)30059-2

Appendix 1: Indications for Laminar Flow Ventilation in Orthopaedic Theatres

Table 1: Indications for Laminar Flow Ventilation in Orthopaedic Theatres

 **All "Green Light" cases require laminar flow ventilation**	 **All "Amber Light" cases may require laminar flow ventilation depending on surgeon preference**	 **All "Red Light" cases do NOT require laminar flow ventilation**
1. All joint replacement surgery **2.** All major implant surgery including *i.* Hip fracture fixation *ii.* Fracture fixation of all long bones (femur, tibia, humerus, radius & ulna shafts) *iii.* Spine fracture fixation *iv.* Open fractures *v.* Anticipated operating time >115 minutes[4] **3.** All open spinal surgery	**1.** ORIF of closed hand & wrist fracture fixation **2.** ORIF of closed foot & ankle fracture fixation **3.** Arthroscopic procedures requiring an implant e.g., suture anchor **4.** Open soft tissue washout involving joint **5.** Repair of tendon or ligament using implant/graft **6.** Patients with risk factors for SSI including: *i.* BMI >35 *ii.* Significant comorbidities *iii.* Diabetes *iv.* Smoking *v.* Elderly	**1.** All closed operations e.g., manipulations of joints **2.** Arthroscopic procedures NOT requiring implant **3.** Open operations NOT requiring an implant e.g., wound washout **4.** All musculoskeletal injections **5.** Removal of metal