SUSQI PROJECT REPORT

Extending the life of anaesthetic circuit tubing and rationalising our suction waste stream

Team Members:

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Background:

Plastic is ubiquitous in healthcare with the NHS estimated to produce around 2,500 tonnes of plastic waste every day.(1) It is associated with multiple harmful environmental and healthcare impacts during production, use and disposal.(2)

Plastic breathing tubing is routinely used to connect patients to anaesthetic machines for ventilation and oxygenation enabling surgery under general anaesthesia. It may also be used to deliver nitrous oxide analgesia in the operating theatre. The tubing is gaining an increasing role in facilitating removal of Entonox from the ambient environment to protect staff from unsafe occupational exposure, particularly on labour wards. At our trust, we anticipate the introduction of Entonox destruction is implemented and following this, we project our usage of circuit tubing could increase to over 22km annually. The tubing is currently disposed of in the offensive waste stream where it is incinerated with energy from waste recovery.

Breathing tubing for anaesthetic machines is validated by the manufacturers for 7 days use.(3) This is an arbitrary duration and lacks scientific basis. They are effectively protected from contamination with respiratory pathogens by use of a single-patient use bacterial and viral filter. However they are not a sterile medical device and in practice, use varies from very little or no use in areas such as obstetrics where general anaesthesia is rare to very frequent use in areas such as emergency theatres which may have a high case throughput and work 24/7.

Suction waste in the operating theatre is collected in plastic bags which should not be disposed of in the offensive waste stream because they are liquid and risk leakage. In the past, gelling agent was used to solidify the waste. In 2020, the National Patient Safety Agency issued an alert, restricting the use of gelling agent to “exceptional use only via a specialist team”.(4) This led to the indiscriminate removal across our trust and suction waste in our maternity unit is now disposed of by high temperature incineration as anatomical waste in a rigid single-use bin.

Specific Aims:

Circuit tubing

1) Conduct a study of the robustness of circuit tubing to determine whether it is reliably durable enough to use outside the 7 day or single patient-use guidance.
2) Gain an understanding of the infection-control and governance implications of changing practice.
3) Evaluate staff attitudes to extending the life of circuit tubing.
4) Estimate the potential financial and carbon savings of changing from a 7 day replacement cycle to a 31 day cycle.

Suction waste

5) Explore the governance attitude to instituting a derogation permitting the use of polymer gelling agent in the operating theatre environment.
6) Calculate the carbon savings of changing from rigid waste bins to polymer gelling agent and offensive waste disposal.
7) Survey staff to gauge the impact and their support and for this change.

Methods:

Circuit tubing

The product is validated for 7 days but has not been demonstrated to fail after 7 days as part of the validation process. Therefore, this duration is arbitrary. The product does not need to be sterile, is not intended to be single patient use and the bacterial/viral filter is trusted to prevent respiratory pathogens contaminating the circuit and causing transmission of hospital acquired respiratory infections. If the inside of the circuit is contaminated, it is in continuity with the inside of the anaesthetic machine which would then also have to be assumed to be contaminated.

Whilst theatre staff universally knew the requirement to change the circuit every 7 days, there was inconsistency about changing the reservoir bag which is also in continuity with the inside of the circuit. Therefore there is no rationale for changing the circuit either between every patient use or every 7 days from an infection control perspective. There is also no rationale for changing some parts of the circuit but not the reservoir bag or spirometry circuit. We conducted a survey of anaesthetic staff to gauge willingness and attitudes to extending the life of anaesthetic tubing.

We estimated a worst case number of uses over a period of a month and trialled robustness by subjecting a circuit to double this number of connections to the catheter mount and to a tube holder. To determine the maximal feasible number of circuit uses within one month, we suggested 20 patients in a 24 hour period would represent a very high turnover of cases. Over 31 days this would result in 620 circuit connections and disconnections. To build in a safety factor we doubled this and tested the circuit 1,240 times connecting it to the catheter mount and inserting the same area of tubing into a tube holder. We then put the circuit through an automated anaesthetic machine check to test the integrity of the circuit, checking it was intact and functional with no leaks. This represents an

unrealistically heavy usage and supports the extension of the usable duration from a robustness perspective.

We will now take this to our directorate governance group to gain approval to introduce the change at Jessops (three theatres) for a period of 3 months as a pilot. If successful we will then roll out across all our theatres.

Suction waste
We will estimate the current carbon footprint of disposing of our suction waste in the current stream and model the use of gelling agent and disposal in the offensive waste stream. We will also survey staff to gauge any impact on them and their level of support for changing the handling of suction waste. We will then trial some gelling agent products to determine usability.

Measurement

Patient outcomes:
We will consult governance and infection control groups to provide external assurance of the safety of extending circuit-tubing lifetime. Following implementation we will use the regular incident reporting system (datix) to provide surveillance for emerging problems.

We do not anticipate any change to patient outcomes from either project.

Population outcomes:
It is not possible to quantify the potential population benefits in this study. However any reduction in material use, waste production and particularly local air pollution from transportation will have a public health benefit and financial savings can be redirected to more productive patient care.

Environmental sustainability:
Circuit tubing
We will obtain procurement data to quantify the number of circuits purchased each year.

To estimate the carbon footprint of the tubing, we will identify the different components and materials used to construct the breathing circuit, reservoir bag and spirometry tubing. We will use the product specifications supplied by Intersurgical to estimate the relative weight of each component of the product and packaging and then apply emissions factors from the BEIS UK government Database 2023 to calculate the carbon emissions associated with the product and packaging. Two plastic materials comprising minor components of the circuit do not have individual emissions factors and so for these, a mixed plastics factor will be used. We will apply emissions factors to account for transport from their place of manufacture to the NHS Supply Chain hub that supplies our hospital. We will apply appropriate emissions factors for the offensive and domestic waste streams. Disposal in the offensive waste stream is usually by low temperature incineration and energy from waste.

Suction waste
If our suction waste were gelled, we could dispose of it through the offensive waste stream. Anatomical waste is incinerated at high temperature with a correspondingly much larger carbon

footprint. We will calculate the relative carbon footprints and weight of single-use rigid plastic anatomical waste bins that could be reduced.

Economic sustainability:
We will calculate the potential cost saving from reduction in purchasing tubing and paying for waste disposal using figures provided by our procurement and waste management teams.

We will calculate the potential cost reduction from gelling and converting our suction waste stream from anatomical to offensive.

Social sustainability:
We will conduct a survey to identify anaesthetic staff's attitudes towards the proposed changes and how they perceive the time and effort saving of reduced circuit changes and gelling and disposal of suction waste in the offensive wastestream.

We will survey our operating department practitioners to gauge their thoughts about our proposed intervention, sending a Microsoft Forms survey to all ODPs on the group whatsapp.

Results:

Patient outcomes:
Governance and infection control are supportive in principle. Following completion of the study, we will formally submit it to our directorate governance group for approval. Our questionnaire uncovered widespread confusion and variation in practice relating to changing different components of the circuit and a misunderstanding of the infection control implications. There was a presumption that extending the period between changing the circuit tubing would lead to an increased infection risk. However there was not the same concern expressed for other components of the circuit equally exposed to the patient (spirometry, reservoir bag, inside of anaesthetic machine, CO2 line and watertrap). This is irrational.

Suction waste:
We have undertaken a risk assessment and obtained a derogation allowing the use of gelling agent in the operating theatre environment.

Environmental sustainability:
Circuit tubing
A reduction in crude oil use for virgin plastic production, reduced carbon production, reduced air pollution from manufacturing and incineration and other negative environmental life cycle impacts will have a positive environmental impact.

Based on numbers obtained from procurement, potential carbon savings from changing from 7-day changes to monthly change are 3,302 kgCO2e per year. The weight of plastic saved would be 1,245 kg annually. Based on our modelled numbers potential carbon savings are 7,887 kgCO2e and the weight saved would be 3,191 kg annually.

The actual potential saving is likely to lie between these two figures of **3,302-7,887 kgCO2e**, equivalent to driving between 9,752-23,293 miles in an average car. However, we should be working to a standard practice and if we were to move towards this, the higher figure would be representative.

Suction waste

Over a month period of observation, our average suction volume per case was 565ml. We estimate from our cell salvage machine logs over the previous 6 months, the volume of fluid collected when cell salvage is used but not infused is 1,155ml and when it is infused is 2,283ml. Information from procurement shows we have used 2,176 suction liners, 774 collection kits and 300 processing kits. Assuming a 7g sachet of silica gel solidifies 1,200ml of fluid(5), we estimate we would need 3,250 (1 for each suction liner, 1 for each collection only cell salvage, 2 for each processed cell salvage) sachets = 22.75kg silica gel. We dispose of 5 suction liners or one cell salvage set per rigid bin and therefore calculate we have used 1,210 polypropylene bins each weighing 1,140g.

Our suction waste stream gelled with silica-based gelling agent (excluding transport emissions from manufacture to our Trust) results in 986.98 kgCO2e. Our suction waste stream as currently disposed of in rigid polypropylene bins results in 9,244.74kg CO2e emissions(6).

Converting to gelling and disposing our suction waste in the offensive wastestream would result in **8,257.76 kgCO2e** saved, equivalent to driving 24,388 miles driven in an average car.

Economic sustainability:

Using numbers from procurement, we estimate our circuit tubing cost to be £27,902.40. Assuming a reduction from weekly to monthly changes, the estimated cost would be £6,415.94, a saving of £21,486.46.

Estimated costs (excluding waste) are £66,448.96 for the modelled scenario reducing to £15,341.76 if we changed from weekly to monthly circuit changes saving £51,107.20 annually.

Suction waste

We estimate we use 1210 rigid 30L anatomical waste burn bins at a cost of £7840.80 per year. We estimate we would save £3153 on disposal by changing from anatomical to offensive waste stream. Overall, excluding and offensive waste bags which we have considered immaterial, this change has the potential to save £10,487 if implemented across maternity theatres.

Social sustainability:

There were 13 responses to our ODP survey. All respondents were concerned about plastic waste in the workplace. 11/13 (85%) changed the circuit weekly. However there was wide-variation in changing components of the circuit other than the corrugated tubing with 8/13 (62%) changing the spirometry set but only 5/13 (38%) changing the reservoir bag.

There was widespread acknowledgement that the proposed intervention would reduce plastic waste and save money. 9/13 (69%) thought it would save them time and effort. 7/13 (53%) thought the current policy, as they understood it, didn't make sense, demonstrating approval for our proposed changes.

10/13 (77%) thought gelling and disposal in a bag was the best solution to suction waste disposal in Jessops. 5/13 (38%) of respondents thought gelling waste instead of boxing it would reduce their workload, the remainder thought it would have a neutral effect. Nobody thought it would add to their workload.

Discussion:

It has been challenging to get reliable numbers from either the manufacturer or our trust procurement department for the number of circuits we use annually. This could be a result of supply chain pressures resulting in substitution of products when they are scarce and the variety of products purchased making it difficult to identify all the products that have been used. The Trust has 117 anaesthetic machines in our inventory which should all have a circuit change every week. We have therefore modelled usage and potential savings based on procurement numbers and an assumed scenario where every machine has a circuit change every week as per manufacturer's guidance. For this scenario, we have assumed all circuits are 2.4m long as this is our most commonly used circuit and we thought to represents a pragmatic compromise between shorter and longer circuits. It also became apparent that many of our reservoir bags are connected by a 60cm limb of breathing tubing which is not supplied separately. Therefore, to replace this, staff open a circuit, chop 60cm of breathing tubing off it and discard the rest, potentially doubling the product usage. This has not been accounted for in our modelling but would have a neutral to positive effect on our carbon, cost and plastic savings.

In recent months, our Trust has experienced supply-chain issues with circuits and they have not always been reliably available. This study provides reassurance that it is safe to operate outside of the manufacturer's guidance.

It has been quite easy to gain acceptance in principle for gelling suction waste. It highlights the tendency to make changes that have a deleterious effect on the environment and costs without considering the consequences and alternatives.

Conclusions:

Our study supports the extension of the usable life of anaesthetic tubing from 7 days to 31 days. Changing the disposal of our liquid suction waste from anatomical to the gelled offensive waste-stream would be associated with >8 tonnes CO2e saving annually and is supported by staff. These changes would be associated with financial, carbon, material use, waste, local air pollution, congestion and staff time savings.

There is a proposal to implement a scavenging system for Entonox on labour ward in the near future. The proposal currently advocated a single use exhalation limb made up of breathing tubing which would dwarf our current usage and expenditure. This study provides support for this expiratory limb tubing to be multiple patient use. Reverting to gelling suction waste is a safe, cost-effective, environmentally advantageous change that is accepted by staff.

References and Resources

1) Obtained from Intersurgical UK https://uk.intersurgical.com/products/anaesthesia/adult-circle-breathing-systems accessed 21/11/23.
2) Innovate UK. Towards more sustainable use of plastics in healthcare. 2/3/22 https://iuk.ktn-uk.org/news/towards-more-sustainable-use-of-plastics-in-healthcare/ accessed 21/11/23
3) Healthcare Without Harm Europe. Measuring and Reducing Plastics in the Healthcare Sector. Sept 2021 https://noharm-europe.org/sites/default/files/documents-files/6886/2021-09-23-measuring-and-reducing-plastics-in-the-healthcare-sector.pdf accessed 21/11/23.
4) Risk of death and severe harm from ingesting superabsorbent polymer gel granules National Patient Safety Agency, London. https://www.england.nhs.uk/wp-content/uploads/2020/02/PS_Alert_Polymer_28_Nov_2019_FINAL.pdf (accessed 27/11/23)
5) Vernacare Vernagel specifications. https://clhgroup.co.uk/janitorial/odour-control/odour-neutralisers/vernagel-absorbent-powder-sachets#full-description (accessed 4/12/23)
6) Greenhouse gas reporting: conversion factors 2023 - GOV.UK (www.gov.uk) accessed 21/11/23.
7) Ecoinvent (source not publicly available)

Critical success factors

Please select one or two of the below factors that you believe were most essential to ensure the success of your project changes.

People	Process	Resources	Context
☐ Patient involvement and/or appropriate information for patients - to raise awareness and understanding of intervention x Staff engagement ☐ MDT / Cross-department communication ☐ Skills and capability of staff ☐ Team/service agreement that there is a problem and changes are suitable to trial (Knowledge and understanding of the issue) ☐ Support from senior organisational or system leaders	☐ clear guidance / evidence / policy to support the intervention. ☐ Incentivisation of the strategy – e.g., QOF in general practice ☐ systematic and coordinated approach ☐ clear, measurable targets ☐ long-term strategy for sustaining and embedding change developed in planning phase ☐ integrating the intervention into the natural workflow, team functions, technology systems, and incentive structures of the team/service/organisation	☐ Dedicated time ☐ QI training / information resources and organisation process / support ☐ Infrastructure capable of providing teams with information, data and equipment needed ☐ Research / evidence of change successfully implemented elsewhere ☐ Financial investment	☐ aims aligned with wider service, organisational or system goals. ☐ Links to patient benefits / clinical outcomes ☐ Links to staff benefits ☐ 'Permission' given through the organisational context, capacity and positive change culture.