Could we improve our anaesthesia carbon footprint?

By Yorkshire Vets, IVC Evidensia

RCVS Knowledge Quality Improvement Award Champion 2024

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Introduction

Yorkshire Vets is a tier 3 first-opinion hospital and part of the IVC Evidensia Group, with 9 Registered Veterinary Nurses (RVNs), 2 Student Veterinary Nurses (SVNs) and 2 nursing assistants. We have 14 Veterinary Surgeons (VS) across 5 practices.

Volatile agents such as isoflurane and sevoflurane are used for the maintenance of anaesthesia in most veterinary practices in the UK. These agents undergo minimal metabolism in the body and around 95% are eliminated through exhalation into the environment. These waste gases can have a deleterious greenhouse gas effect on the environment.

Oxygen (O2) is used as a carrier gas for these volatile agents and the fresh gas flow rate (FGFR) of O2 directly alters the volume of isoflurane. Veterinary practices can therefore lower their environmental impact by utilising lower flow anaesthesia. This can be achieved by the use of re-breathing circuits, accurate FGFR calculations, and capnography[1].

Our QI initiative looking at our anaesthesia carbon footprint was chosen after realising that 1 hour of minimum alveolar concentration (MAC) anaesthesia with isoflurane at a FGFR of 1L /min equated to a 12-mile drive in regard to the carbon footprint of isoflurane use. As a practice, we take part in the IVC Positive Pawprint Initiative, and it hit hard that we were causing such a negative impact.

We realised that low-flow anaesthesia was not being routinely practised and that non-rebreathing circuits were being used almost exclusively, with minimal use of capnography.

We had existing FGFR cheat sheets in practice, meaning FGFRs were not being routinely calculated based on each patient's weight, respiratory rate (RR) and tidal volume (TV). There was some concern about high oxygen rates and a lack of confidence in using FGFR calculations accurately. This led to discussions about why this was the case, and it was decided to perform an audit of the anaesthetic charts to determine the primary causes and level of overuse to see if we could make changes to improve our patient safety and carbon footprint.

I am an RVN and clinical supervisor, and Emily is a second-year SVN. We completed this project together as part of Emily's clinical governance training, with the aim of improving our clinical protocols.

Aims of the clinical audit

Following the initial audit to establish the current state as the benchmark, we discussed what we would like to see improve. We aimed to:

- Improve the understanding of all team members that what we do has an impact on our patients, the environment and the ozone layer.
- Encourage a pro-active approach to low-flow anaesthesia with the use of re-breathing and mini-lack circuits.
- Improve knowledge and confidence with the use of calculations and capnography in optimising FGFRs.

To meet these aims, we set targets that we felt were achievable by encouraging team compliance and providing in-house training. These were:

- Reduce the FGFR per patient by 50%,
- Increase the use of re-breathing circuits for patients over 10kg by 50%,
- Increase the use of mini-lack circuits in patients under 10kg by 75%,
- Increase the use of capnography in at least 66% of all anaesthetics.

Actions

This specific initiative felt bigger than a one-person job, so Emily and I made ourselves champions, ensuring we gathered all data required in a consistent way, communicated regularly with the whole team and were available to offer support and guidance where needed.

To establish the baseline before initiating any changes, we retrospectively looked at 82 completed general anaesthesia (GA) charts for October 2023. This provided a total of 66.9 hours of anaesthesia time. Charts that contained incomplete or insufficient data were excluded from the audit. We developed a FGFR calculator in Excel[2] and extracted the following data from the GA charts, plotting the information on the Excel spreadsheet:

a) The total oxygen used during the procedure (FGFR used x length of procedure).

b) The amount of oxygen that would have been used if the operator had calculated the FGFR (weight x TV x RR x circuit factor x length of procedure).
c) The amount of oxygen that would have been used had the operator used a more appropriate circuit (i.e. patients over 15kg – circle system over parallel lack, patients 2-10kg – mini lack over T-piece).
d) The length of time of the procedure.
e) Whether a capnograph had been used (yes/no).
f) Potential oxygen saved if FGFR was calculated (A minus B).
g) Potential oxygen saved if a more appropriate circuit had been used (A minus C).

We also attempted to calculate our current isoflurane usage as well as our potential isoflurane usage which was achieved through an online calculator[3]. We set the average isoflurane rate at 2% rather than the generic MAC as this was more in line with our practice usage.

Following the initial audit, we realised that we had significant data to hold team discussions with nursing colleagues. These were held over several days to ensure all team members were included. We discussed what we were doing, why we were doing it, what results we were hoping to achieve, and solutions to potential barriers:

The use of fresh gas flow rate calculations

- Nurses felt that adding space for recording calculations to the anaesthetic form would improve compliance.
- In-house training was provided and the purchase of additional calculators in clinical areas aimed to facilitate task completion.

The use of re-breathing circuits

- Nurses had a general lack of confidence in using the circle circuit and the lack of availability in the prep room meant that they were unlikely to transfer circuits once in theatre.
- A 'buddy' system was introduced where more confident nurses shadowed those less confident for appropriate anaesthetic procedures to provide support and guidance.
- Additional circle circuits were purchased for the prep room so that anaesthetics could be more easily started using this system.

The use of mini-lacks over t-pieces

- Nurses were unaware that these were suitable for patients between 2 and 10kg and expressed concern that there were not enough mini-lack circuits available.

- Discussing their appropriate use as a team, purchasing additional mini-lacks and reducing the number of t-pieces available aimed to encourage uptake in choosing the mini-lack as an appropriate circuit.

The use of capnography

- Most nurses were happy with using the capnograph but weren't aware this could be used for further titration of oxygen.
- Further in-house training on the use of capnography was provided for the nursing team.

I ensured that my knowledge of the subject was sound and that I was setting a good example, for instance, I started using re-breathing circuits in all my patients over 15kg, putting myself forward to train less confident colleagues and discussing successes and failures with the team. I noticed another colleague was happier using lower flow rates than I was, so we discussed this and looked into the evidence – this led to further improvement in our FGFRs as well as team collaboration. As Emily is an SVN with minimal experience of low flow anaesthesia I ensured that she was as happy as possible in what she needed to do and trained her in circle use and capnography use.

Results

October 2023

We were shocked at the results of our first audit. From the 66.9 hours of anaesthesia undertaken in October, we calculated:

- Total actual O2 use = 18, 673 litres
- Average FGFR per patient = 4.69 L/min
- Total actual isoflurane use = 1,913ml
- Hourly isoflurane use = 28.6ml
- Re-breathing circuit use in patients over 15kg = 0%
- Circuit use in patients under 10kg = t-piece 74%, mini-lack 26%
- Percentage of capnograph use = 35% of patients

We then calculated the potential reduction that could have been achieved if the FGFR had been calculated based on the patient's weight and if a more appropriate circuit had been selected:

- Potential total O2 use if FGFR calculations used = reduced to 13,156.5 litres.

- Potential total O_2 use if a more appropriate circuit is selected = reduced to 7,926 litres (a massive 58% potential saving!)
- Average FGFR per patient = 1.97 L/min
- Potential total isoflurane use = 816ml
- Potential hourly isoflurane use = 12.12ml

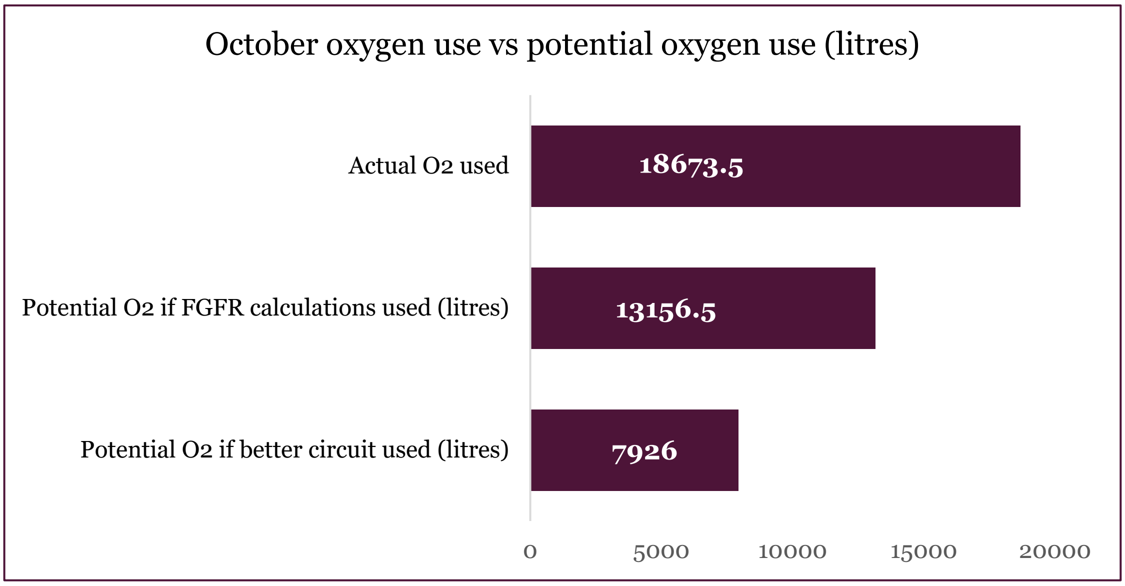

Figure 1: Comparison of actual oxygen use vs potential reduction if FGFR calculated accurately and more economical circuits selected during October 2023

We used the mileage estimate of 1 hour at MAC anaesthesia with isoflurane = 12 miles to see how many miles our anaesthesia equated to in relatable carbon footprint terms:

- 12ml/hr (1 litres) x 4.69 (average L/min) = 56.28 miles per hour in terms of carbon footprint.
- 56.28 miles p/h x 66.9 hours of anaesthesia = equivalent of 3765 miles during October

November 2023

A repeat audit was carried out in November, gathering data as before. A further 66.9 hours of anaesthesia were analysed from anaesthetic charts after implementing the changes we discussed to assess if we had made any improvements in the FGFR, appropriate circuit use, and a reduction in our carbon footprint.

We opted to use the anaesthetic time as an audit point rather than the total number of patients as we felt this would be more relevant and it was appreciated we could not gather identical data due to differing patient circumstances, weights, procedures, and team members performing the anaesthesia procedure. However, we were happy that we would have sufficient comparable data for analysis despite this.

The reaudit results were better than we initially hoped to achieve:

- Total actual O2 use = 8,722 litres. This was a huge reduction from October of 9,951 litres!
- Average FGFR per patient = 2.17 L/min - a 54% reduction.
- Total actual isoflurane use = 893ml – a 53% reduction.
- Hourly isoflurane use = 13.35ml – a 53% reduction.
- Re-breathing circuit use in patients over 10kg = increased from 0% to 54%.
- Circuit use in patients under 10kg = t-piece 3%, mini-lack 97%. All team members now prefer the mini-lack circuit and intend to keep using them for these patients. No team member interviewed experienced any concerns.
- Percentage of capnograph use = increased from 35% of patients to 53% of patients. Although this is lower than our target, we are pleased to see this increase and have purchased a portable side-stream capnograph to aid its use during dental procedures.

We again estimated how many miles our anaesthesia equates to in order to consider our carbon footprint in relatable terms:

- 12ml/hr (1 litres) x 2.17 (average L/min) = 26.04 miles per hour in terms of carbon footprint.
- 26.04 miles p/h x 66.9 hours of anaesthesia = equivalent of 1,742 miles during November

This is a difference of 2,023 miles compared to October, or the equivalent of driving from Yorkshire Vets Armley to Andorra, or London to Rome, and back!

	October 2023	**November 2023**
Total O2 use (litres)	18,673	8,722
Average FGFR per patient (L/min)	4.69	2.17
Total isoflurane use (ml)	1,913	893
Hourly isoflurane use (ml)	28.6	13.35
Re-breathing circuit use	0%	54%
T-piece use	74%	3%
Mini-lack use	26%	97%
% use of capnograph	35%	53%
Mileage equivalent	**3,765 miles**	**1,742 miles**

Table 1: Comparison of audit results October vs November 2023

Impact of intervention

Our initiative resulted in a surprisingly positive outcome in terms of team participation. All team members understood what we were aiming for and why. Discussions were happening daily between team members all looking at ways to improve what we were doing and challenging our proposals even further. For example, we had previously proposed a minimum of 2L/min on non-re-breathing circuits, however after discussion, we have reduced this further to 1 L/min. We also changed our minimum patient weight for the circle from 15kg to 10kg.

A specific barrier to this initiative was encouraging colleagues to use the re-breathing circuits. Many had perceived poor experiences with this equipment, particularly with struggling to stabilise light anaesthesia. We also found that some team members felt apprehensive about going below certain FGFRs. It was important to ensure that these colleagues felt fully supported and had another nurse with them until they felt confident. To build on this further and continue to improve confidence, we are looking at providing additional training by an external provider.

There was also a cost barrier to be considered when requesting the purchase of additional equipment. To make the case for this additional spending, we needed a committed effort from the whole nursing team to implement the new protocols into their anaesthetic practise, demonstrating how the cost could be offset by the financial savings of using significantly less isoflurane and oxygen. We would like to take the reduction in carbon footprint from isoflurane use further by considering installing sevoflurane anaesthetic machines as we are aware that sevoflurane has a much lower environmental impact at around a third of isoflurane, but this will take time for decisions to be made.

General barriers we have encountered are that due to us being a big team with several branches it can be very difficult to communicate changes effectively to every team member. Occasionally changes have been made that weren't effectively communicated to everyone which resulted in general confusion. Therefore, with this particular project, we ensured that all team members were directly involved in discussions and given the opportunity to ask questions or voice concerns.

Since the introduction of QI to the nursing syllabus and skills logs in the past several years I have found that early introduction to these principles has made it much easier to introduce them into practice. We have had several excellent initiatives performed by students who have grown into RVNs with a greater understanding of the role we have in QI.

Summary

Clinical audit is a process for monitoring standards of clinical care to see if it is being carried out in the best way possible, known as best practice.

A clinical audit can be described as a systematic cycle. It involves measuring care against specific criteria, taking action to improve it, if necessary, and monitoring the process to sustain improvement. As the process continues, an even higher level of quality is achieved.

What the clinical audit process is used for

A clinical audit is a measurement process, a starting point for implementing change. It is not a one-off task, but one that is repeated regularly to ensure ongoing engagement and a high standard of care.

It is used:

- ⇒ To check that clinical care meets defined quality standards.
- ⇒ To monitor the changes made to ensure that they are bringing about improvements and to address any shortfalls.

A clinical audit ensures concordance with specific clinical standards and best practices, driving improvements in clinical care. It is the core activity in the implementation of quality improvement.

A clinical audit may be needed because other processes point to areas of concern that require more detailed investigation.

A clinical audit facilitates a detailed collection of data for a robust and repeatable recollection of data at a later stage. This is indicated on the diagram wherein in the 2nd process we can see steps 4, 5 and 6 repeated. The next page will take you through the steps the practice took to put this into practice.

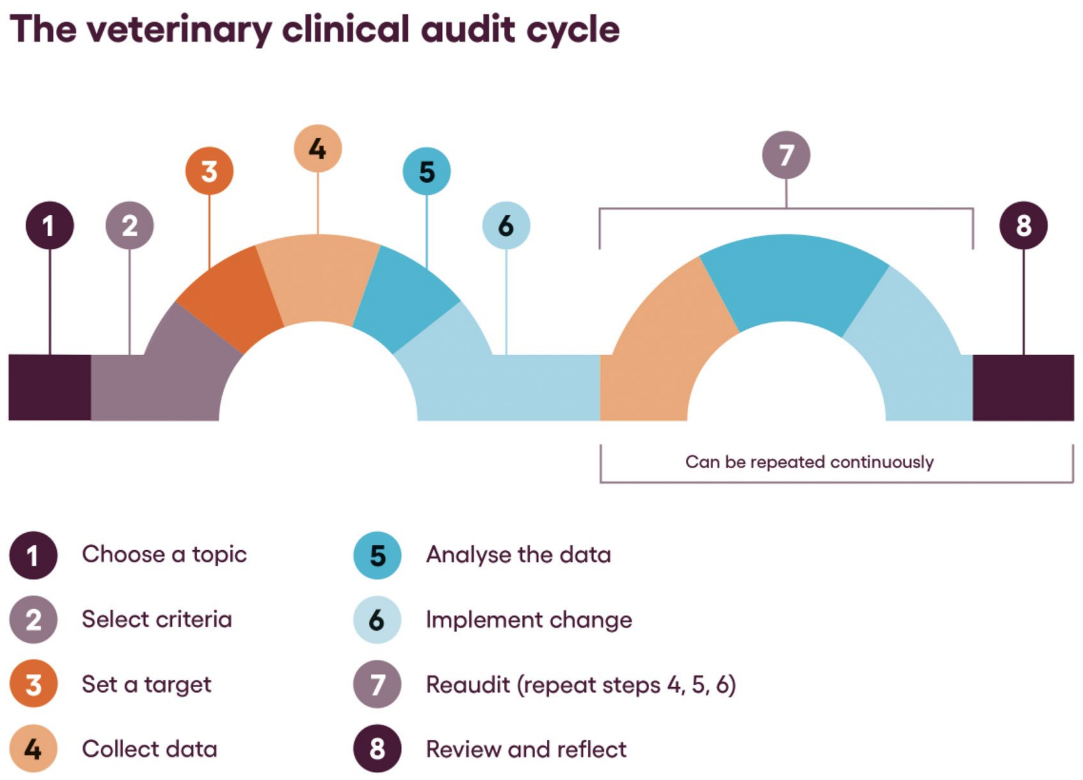

Figure 1: The Veterinary Clinical Audit Cycle by RCVS Knowledge. Available from www.rcvsknowledge.org. Developed by the Royal College of General Practitioners www.rcgp.org.uk/qi-ready

1. Choose a topic relevant to your practice

The topic should be amenable to measurement, commonly encountered and with room for improvement. The practice undertook a retrospective audit of patients undergoing anaesthesia to determine whether the fresh gas flow rate (FGFR) and consequently isoflurane consumption was appropriate and to measure their carbon footprint.

2. Selection of criteria

Criteria should be easily understood and measured. Retrospective data was collected from general anaesthetic monitoring charts. Charts with incomplete or insufficient data were excluded from this audit. Total anaesthesia time was used as the audit criteria to ensure comparable data collection in both audit cycles.

3. Set a target

Targets should be set using available evidence and agreeing best practices. The first audit will often be an information-gathering exercise, however, targets should be discussed and set. Baseline data was collected to establish the benchmark. Targets were then discussed and set to see a reduction in the FGFR per patient by 50%, an increase in the use of re-breathing circuits for patients over 10kg by 50%, an increase in the use of mini-lack circuits in patients under 10kg by 75%, and an increase in the use of capnography in at least 66% of all anaesthetics.

4. Collect data

Identify who needs to collect what data, in what form and how. Data was collected by the author and a student veterinary nurse. Data was recorded on an Excel spreadsheet, including the FGFR the patient received during the procedure, whether a capnograph was used, whether the most appropriate circuit was used and the length of the procedure. The ideal FGFR rate according to the patient's weight and respiration rate was calculated, alongside the difference if an ideal circuit was used.

5. Analyse

Was the standard met? Compare the data with the agreed target and/or benchmarked data if it is available. Note any reasons why targets were not met. These may be varying reasons and can take the discussion from the entire team to identify. The audit showed that there was a deficit of 58% between the ideal FGFR if a calculation had been used alongside an appropriate circuit and the actual FGFR that had been used by teams. No rebreathing circuits were used during October, and t-piece circuit use predominated over the mini lack which has a circuit factor of much less. A lack of time to calculate, a lack of calculations being easily visible to teams, a lack of appropriate circuits and a lack of training on re-breathing circuits were identified as reasons.

6. Implement change

What change or intervention will assist in the target being met? Develop an action plan: what has to be done, how and when? Set a time to re-audit. Discussion identified a need to purchase additional circuits with lower circuit factors and provide in-house training on re-breathing circuits alongside general training around appropriate FGFR and the impact of increased rates (with concurrent isoflurane) on the environment.

7. Re-audit

Repeat steps 4 and 5 to see if changes in step 6 made a difference. If no beneficial change has been observed them implement a new change and repeat the cycle. This cycle can be repeated continuously if needed. Even if the target is not met, the result can be compared with the previous results to see if there is an improvement. Following team discussions and the implementation of new protocols, a re-audit following an identical period of anaesthesia was carried out. It was appreciated that it was not possible to collect the data under identical situations due to different patient weights and teams. However, using total anaesthesia time provided data of sufficient quality for analysis. The results were excellent in most cases, with reduced FGFR rate from 4.69L/min to 2.17L/min, increased use of re-breathing systems in patients over 10kg from 0% to 54% and mini-lack use from 35% to 97%. In terms of the carbon footprint, this resulted in a decrease equivalent to driving 2,023 miles.

8. Review and reflect

Share your findings and compare your data with other relevant results. This can help to improve compliance. Results of the audit are regularly fed back to the team, with further conversations about the impact of anaesthetic gases on their carbon footprint and further improvements that could be made. The project was publicised on social media and client information in the waiting room. The team continue to look at their anaesthetic protocols and plans to update them when required.

References

1. McMillan, M. (2021) Sustainable veterinary anaesthesia: single centre audit of oxygen and inhaled anaesthetic consumption and comparisons to a hypothetical model. *Journal of Small Animal Practice,* 62 (6), pp, 420-427. https://doi.org/10.1111/jsap.13316

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You should reference this resource like this: RCVS Knowledge, Yorkshire Vets, (2024). *Could we improve our carbon footprint?* [Online] Available at www.rcvsknowledge.org/KA-carbon-footprint/

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