Designing a workshop for a Temporal Artery Biopsy simulation.

The neglected TAB, rethinking training

Abstract body:

Purpose: Opportunities to perform a temporal artery biopsy (TAB) during training is limited. Our aim is to present our data on the conduct of a wet lab to teach the steps of a TAB with a simulation model designed for this purpose.

Materials and Methods: The wet lab event included the development of two simulation models, teaching by consultants on the surgical approaches to a TAB, the mapping of the temporal artery with the use of the doppler and practical demonstration with videos. The trainees undertook two biopsies using the models under consultant supervision. Participants were asked to complete a questionnaire to evaluate the pre and post session knowledge, understanding and learning experiences pertaining to TAB.

Results: There were 7 specialist trainees (ST) (ranging from ST1-5) and 3 staff grade surgeons supervised by 3 consultants. The simulation models were developed with pig ureter for the temporal artery by the WIMAT (Welsh Institute for Minimal Access Therapy) team. All participants returned the completed questionnaire. Participants noted significant improvements in their knowledge and understanding pertaining to all domains covered. A lack of knowledge, a lack of procedures previously performed, concern about damaging the facial nerve and lack of senior support/supervision were all identified as reasons as to why trainees get apprehensive when it comes to performing a TAB.

Conclusions: This novel formal teaching event provides a blueprint for deaneries to use in their teaching of TAB’s which can benefit trainees and patients. Modern surgical education benefits from wet labs with expert supervision.

Key words: medical education, ophthalmology, rheumatology, clinical education, curriculum development/evaluation, patient safety, postgraduate training, testing/assessment

Introduction

Giant cell arteritis (GCA), also known as temporal arteritis (TA), occurs in adults and it is the most common form of large vessel vasculitis in this age group. Patients are typically over the age of 50 years, and they can present with a plethora of systemic symptoms which can include headache, jaw pain and vision loss. Patients therefore can present to general practitioners, optometrists, Rheumatologists or Ophthalmologists. Vision loss is irreversible and concerningly if left untreated the initially unaffected eye can lose vision quickly. With GCA there is also a risk of stroke and therefore it is a medical emergency.

There is no single one test to diagnose GCA and a combination of the patient's clinical picture, biochemical markers, and where available ultrasound imaging of the temporal artery and or a temporal artery biopsy (TAB) are used to make a definitive diagnosis. If there is a strong clinical suspicion of GCA however then treatment is initiated with high dose corticosteroids and the aforementioned investigations can be performed soon after starting treatment. According to the British Society for Rheumatology guideline on the diagnosis and treatment of giant cell arteritis [1], a strong recommendation is that a confirmatory test is needed in patients suspected to have GCA. They state that '*either a temporal artery biopsy at least 1 cm in length or an ultrasound of the temporal and axillary arteries, or both'.*

As part of the current ophthalmology specialty training programme in the UK trainees are required to have performed two TAB's during the seven-year training path. The issue with this recommendation and requirement is that firstly you may not have such services available at your hospital and secondly if they are not performed frequently how does one gain experience and become competent as a trainee. This has trainee implications and ultimately affects the quality of patient care and patient safety (both short and long term).

Due to limited opportunities to develop and learn the skills needed to perform a TAB and in the current climate of simulation being used to develop competence, one of the authors (SR) had the idea to organise, plan, design and deliver a temporal artery biopsy workshop, the first of its kind, in the hospital deanery. A structured regular programme of TAB simulation training will help to avoid the outdated and unethical model of 'see one, do one, teach one' which often exists due to the limited training opportunities of TAB.

Materials and Methods

In July 2023, at the WIMAT (The Welsh Institute for Minimal Access Therapy) centre in Cardiff, one of the authors (SR), with the support of two ophthalmology consultants (AH, PW), one vascular consultant surgeon (IW) and two professional specialists (PH and CF) with an interest in medical education, delivered a half day surgical simulation laboratory to teach ophthalmology specialist trainees the knowledge and skills needed to perform a TAB. The workshop consisted of an interactive didactic component followed by simulation training. Emphasis was placed on educating attendees about the 'danger zone' which should be avoided when performing a TAB in order to reduce the risk of damaging branches of the facial nerve. Attendees would later be asked to map out the 'danger zone' on the models used. Case studies, surgical videos and animations were used as teaching tools. This was followed by an integrated and comprehensive series of practical activities applicable to future clinical practice. The attendees worked in pairs for the practical component which allowed for the roles of 'primary surgeon' and 'assistant' and then role reversal. This also enabled active feedback to be provided aiding collaborative learning. Supervision and teaching was provided by the three consultants (PW, AH, IW) present in an approximately 1 consultant:3 attendee pairs ratio. The consultants freely circulated amongst the attendees during the session providing feedback and assistance as required. Each step of the procedure was completed independently by each attendee. The models for simulation training were developed by the authors in house (PH, CF, SR and AH) over a 6-week period. The core ideas regarding the components of the model came from author PH and were refined based on feedback. Ethical approval was not required for this workshop.

Constructing the Models

Initially a protype model was developed by the WIMAT team (PH and CF) prior to the event to test the practicality and feasibility of using such a model. After input from clinicians (AH and SR) the final modified models were altered to be used for the training. Twenty-two models were constructed in total. This represented two models per attendee and two extra models to be trialled by the consultant body on the day of the event to familiarise them with the anatomy and workings of the model.

The model consisted of a suture pad (150mm x 100 mm) with the superficial temporal artery represented by a porcine ureter of approximately 120mm in length, chosen due to its approximation to the temporal artery size (1.9mm vs 1.7mm respectively). The ureter was inserted under the surface membrane at between 5 – 10 mm in depth, as shown in Figure 1, to represent the anatomical variation present in patients.

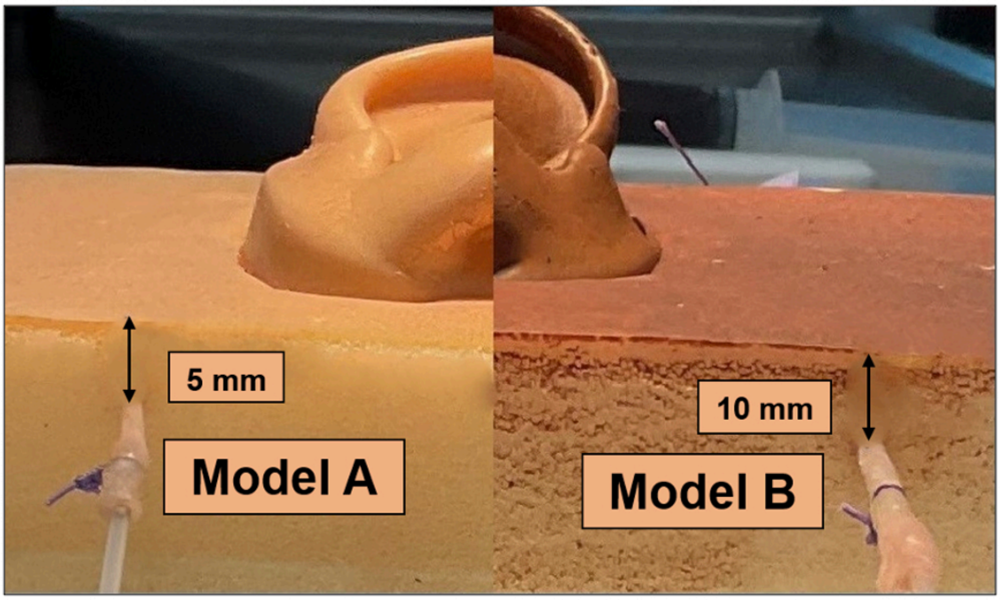


Figure 1 – Images of the models used, showing the variation in depth of the frontal branch of the superficial temporal artery model. Model A, on the left, shows the superficial temporal artery inserted at a depth of 5mm from the surface membrane. Model B, on the right, shows the superficial temporal artery inserted at a depth of 10mm from the surface membrane.

The distal end of the vessel (ureter) was clipped using Ligamax *5*® clips (Ethicon Endo-Surgery) with the proximal end plumbed using a 4.5 Fr *TAUT*® operative cholangiogram catheter (Teleflex Medical, Morrisville NC). To this a 10ml syringe containing simulated blood (Limbs&Things, Bristol) under mild pressure was attached to simulate active bleeding in the event of vessel transection due to suboptimal technique. Additionally, a 3/0 undyed *Vicryl* ®suture (Ethicon) was also tunnelled in proximity to the vessel to represent the temporal branch of the facial nerve to allow participants to acknowledge the risk of damage to the facial nerve, a common complication in TAB. This model was dressed with surgical drapes to simulate the area of exposure required for a TAB thereby concealing the model construction (figure 2).

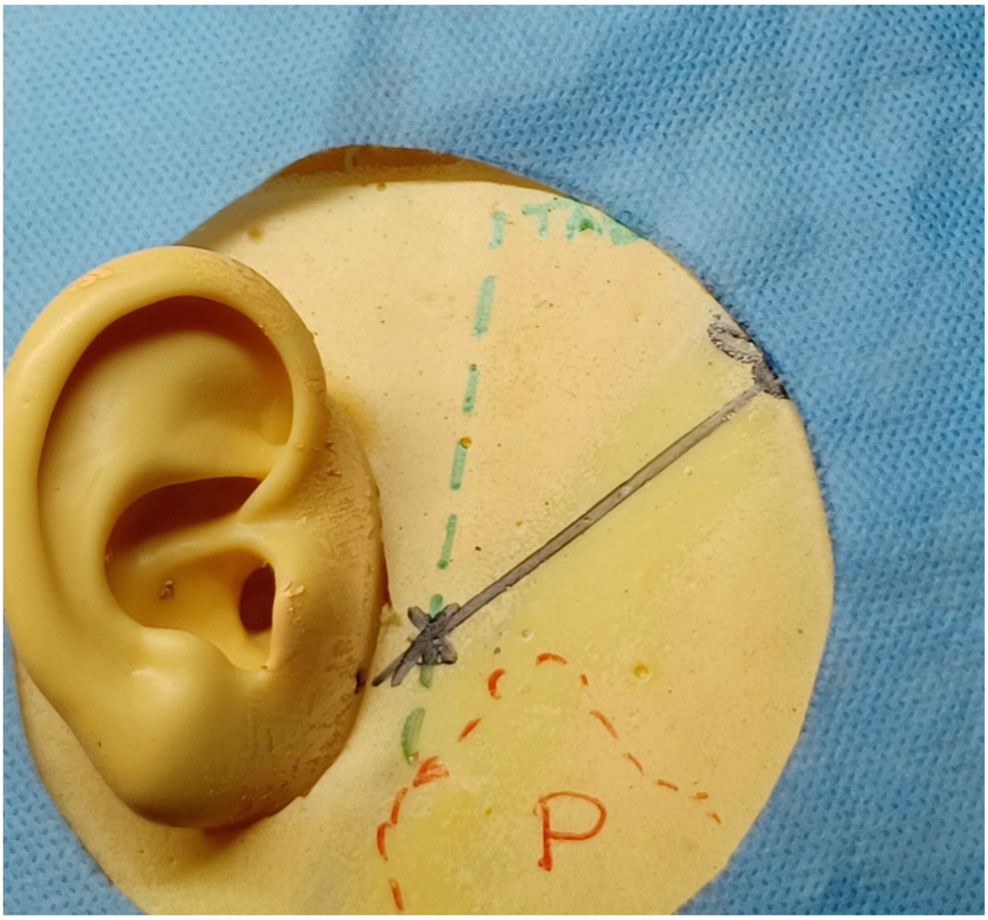
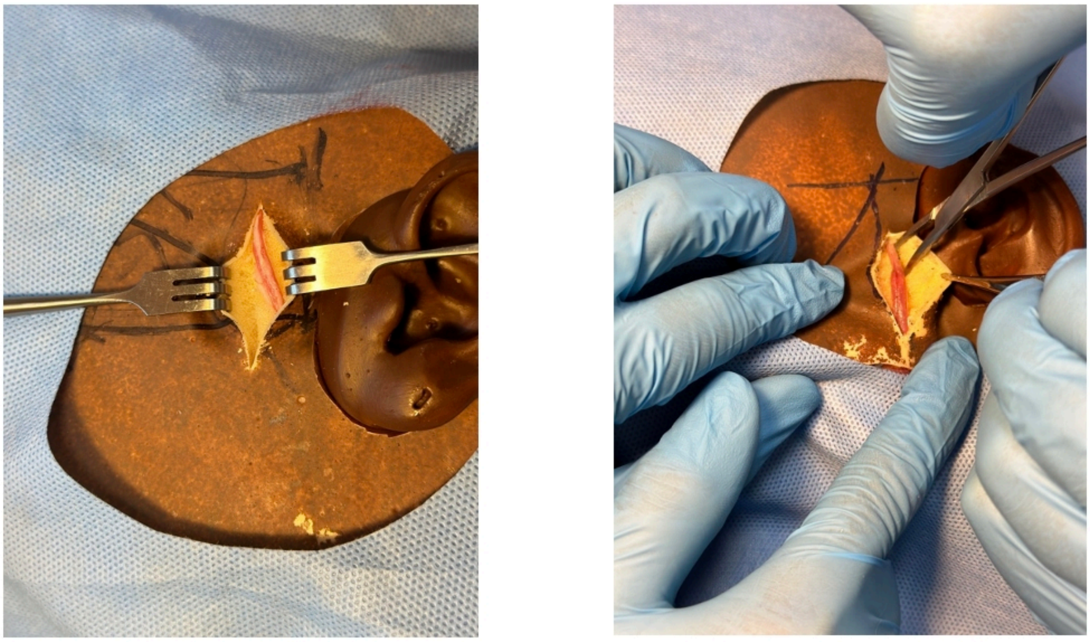


Figure 2 – mapping the temporal artery and depiction of the danger zone.

Moreover, to make it more realistic the model included an attached ear to help attendees judge and appreciate relative and proximal real life anatomy. Models were also painted in various skin tones to represent variation in patient groups and demonstrate the visual differences regarding the subdermal vessels (figure 1).

Model 1 was constructed to be less complex with the temporal artery located superficially. After successfully completing the TAB on model 1, attendees were encouraged to move onto the more complex model (number 2). In this model the temporal artery was located deeper. Figure 4 portrays exposed temporal arteries ready to be biopsied.



(a) (b)

Figure 4 – Portrays exposed temporal arteries ready to be biopsied. (A) This was the more ‘straightforward’ model used as the temporal artery was inserted superficially into the model therefore making identification of it relatively easy. (B) The more complex model. The image shows the deeply situated temporal artery. Moreover marking on the model can be seen which demonstrate the path of the temporal artery and the danger zone to avoid.

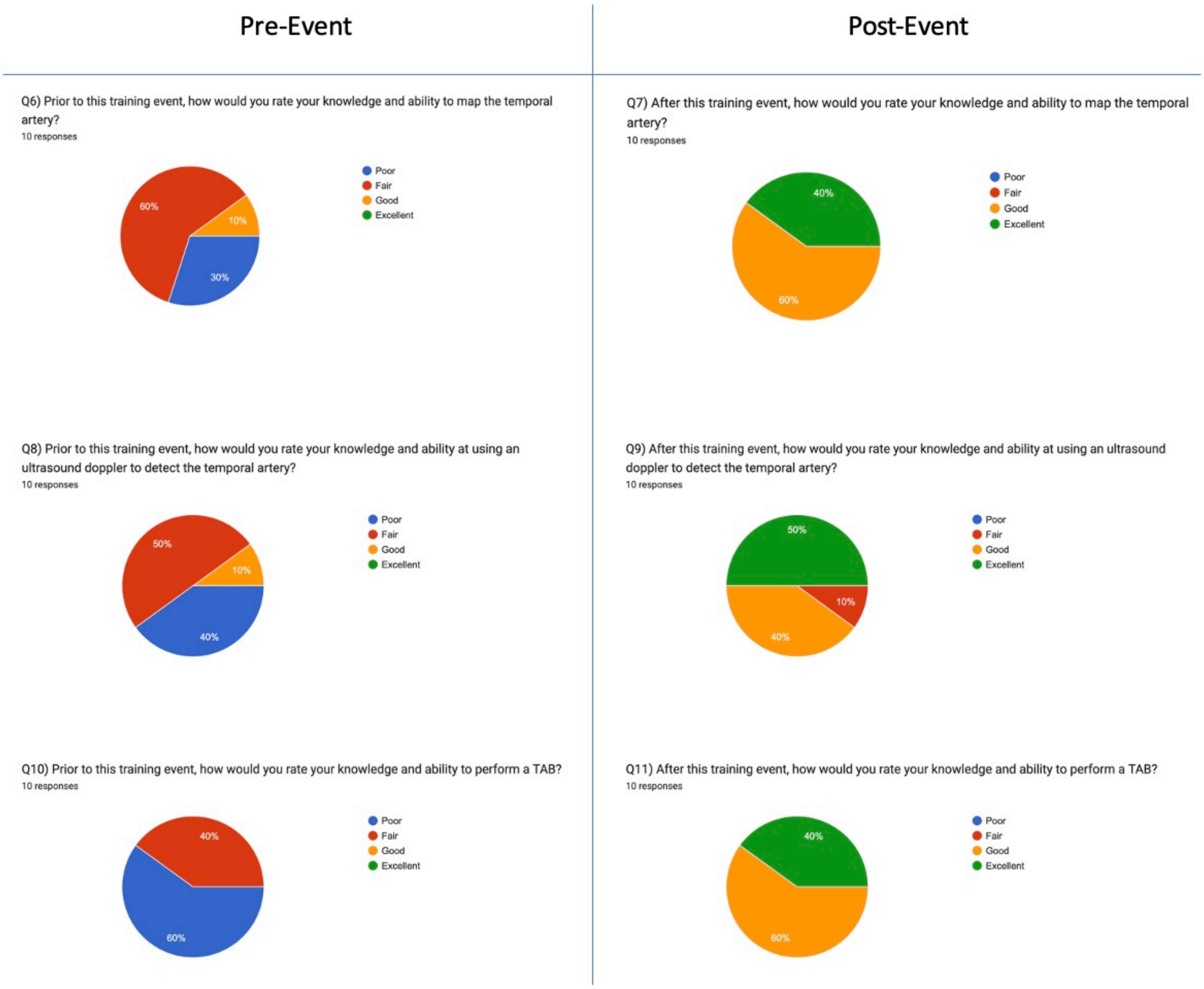
This novel multidisciplinary first of it’s kind simulation lab in Wales, and to the authors’ knowledge in the UK, was open to a maximum of ten ophthalmology trainees. The planned collaboration between different surgical disciplines would enhance the experience of the event as it meant that trainees would get to understand and learn practical hints from a vascular surgeon and ophthalmic surgeons with regards to decision making and their general surgical approach. Participants were asked to complete a 30 item Google Forms Questionnaire (see supplementary material), to help us to evaluate pre and post session knowledge, understanding and learning experiences. To check for statistical significance, between pre and post event data, a paired sample t test was performed, and p values were calculated. The feedback form consisted of a series of mainly Likert-based response items (using poor, average, good and excellent throughout) including some free text response options. Likert scales provide reliable and valid data and are used widely in psychometric research [2,3]. All attendees gave consent for their images from the event to be used. This study adhered to the tenets of the Declaration of Helsinki.

Results

Ten attendees participated in the course and ten completed the end of course evaluation. Of the attendees, 7 out of 10 were ophthalmic specialist trainees (OST) whilst 3 out of 10 were trust grade doctors. There were three year 3 trainees (30%), two were year 5 trainees (20%), one was a year 4 trainee (10%), and one was a first-year trainee (10%). There were 9 out of 10 of attendees from the Wales Deanery and 1 attendee was from the South London Deanery.

In response to the question regarding opportunities to perform TAB at their local hospitals, 6 out of 10 said opportunities were ‘poor’ whilst 3 out of 10 said that they were ‘fair’. Half of the participants stated that the level of training received to perform TAB prior to this event was ‘poor’ whilst 4 out of 10 stated it was ‘fair’. Prior to this event 2 out of 10 of attendees had never performed a TAB, 6 out of 10 had performed one, 1 out of ten had performed two and 1 out of ten had performed three.

Questions 6-11 asked attendees to evaluate pre and post course knowledge, understanding and skills. The general findings from these questions (figure 5 and table 1) demonstrate that across all domains enquired about, attendees stated that their knowledge, understanding and skills had improved. All of the results were statistically significant with p values <0.05. Interestingly 8 out of 10 of attendees felt that vascular surgeons should perform a TAB, 10 out of 10 had only ever received informal TAB teaching and only half were aware of the anatomical danger zone landmark (which contains the facial nerve).



<u>Figure 5</u> – comparing pre and post event knowledge and understanding pertaining to mapping the temporal artery, using an ultrasound doppler to detect the TA and one's ability to perform a TAB.

Table 1 – Comparing the pre and post event results and illustrating their associated levels of statistical significance.

Knowledge and Skills	Pre-Event	%	Post-Event	%	p value
Mapping the Temporal Artery	Poor	30	Poor	0	0.015
	Fair	60	Fair	0	0.015
	Good	10	Good	60	0.0002
	Excellent	0	Excellent	40	0.0002
Using an Ultrasound Doppler Device	Poor	40	Poor	10	0.0002
	Fair	50	Fair	40	0.0002
	Good	10	Good	50	0.0002
	Excellent	0	Excellent	0	N/A
Performing a TAB	Poor	60	Poor	0	0.0002
	Fair	40	Fair	0	0.0002
	Good	0	Good	60	0.0002
	Excellent	0	Excellent	40	0.0002

Paired t test sampling was performed, and p values were calculated.

Question 16 asked, 'do you feel apprehensive about performing a TAB in clinical practice? If so, why?' For this free text response question, unanimously attendees felt more confident after our training, and one stated the following *'I did prior to this event as I lacked basic common knowledge regarding how to perform this procedure. I was also fearful of the nearby anatomical structures and did not want to damage them. Also within my department no members of the ophthalmology team were performing TABs for patients and so senior support/supervision was lacking'.* 70% of attendees had observed between 2-5 TABs in clinical practice.

The models for this workshop were bespokely designed and 70% of attendees stated that the model was realistic compared to human anatomy. Attendees acknowledged an increase in complexity between model 1 (where the temporal artery was located superficially) and model 2 (where it was located deeper within the model), with 50% stating that model 1 provided a level of complexity that was 'easy', whereas 70% stated that model 2 was 'difficult'.

The venue was graded as 'excellent' by 70% of attendees. As part of the course evaluation, attendees were asked to provide an open-ended response on how the course supported their learning needs and how the course could be improved.

Overall the course was very well received, and a selection of feedback comments are listed below:

‘Thank you for curating an excellent training session which was well structured, resourced and run’.

‘A fantastically organised and much needed course for trainees to develop skills in TABs which are hard to come by. Thank you for organising such a brilliant course’.

‘Great venue, great teaching, I would happily have paid for this event had it been run externally’.

Several attendees affirmed an intention to use what they had learnt in their future clinical practice.

Discussion

TAB remains an important tool to diagnose GCA and to rationalise on going treatment however teaching of this important procedure remains largely informal. At the time of writing, a current search of published literature identified no reported methods of practising TAB either using cadaveric specimens or purpose-built models. The models for this workshop were bespokely designed and 70% of attendees stated that the model was realistic compared to human anatomy. A study from 2002 which was carried out at King's College hospital (London) asked: who should be performing TAB's and investigated differences between different surgical specialties (ophthalmologists versus vascular surgeons versus plastic surgeons) performing them. They found that ophthalmologists were achieving the longest average length of biopsies (which reduces the risk of obtaining 'skip lesions') and advocated that ophthalmologists were best suited to performing the majority of biopsies. They were also more likely to re-biopsy if needed [4]. Currently ophthalmology trainees in the UK are required to achieve competence at performing a TAB by the end of their 7th and final year of training. Ideally trainees would be performing TAB's more frequently and throughout their entire training programmes to develop and hone their skills. Due to the challenges associated with this, simulation-based training can help trainees to safely acquire the core skills and knowledge associated with TAB with clear learning objectives.

Unfortunately there are issues related to performing a TAB which means that not every centre offers it as an investigation for example due to a reluctance to perform it by staff. In addition to potentially causing damage to branches of the facial nerve, the more pertinent issue is that GCA does not affect every part of every temporal artery. Therefore it can "skip" around creating so called 'skip lesions'. The situation of a clinically positive but biopsy negative patient is not uncommon. Published literature confirms undesirably high false negative rates and a low yield for biopsy [5]. However, sampling of the incorrect tissue, inadequate sample length and steroid exposure prior to biopsy are potential reasons for reduced sensitivity of TAB's [6,7]. Clinicians therefore can and do opt against performing an invasive TAB (more so when the ultrasound route is available) and regardless treat those with a high clinical suspicion of GCA. The issue with this approach comes later when the Rheumatologists whom such patients will be under long term have to make difficult decisions such as the indications for on-going corticosteroid therapy and the duration of such therapy. Armed with a positive TAB result for GCA, in the face of systemic upset (possibly hypertension, diabetes and osteoporosis) and a worried patient, a Rheumatologist can justify their decisions with respect to on-going steroid therapy. A recent paper from an Oxford group looking into Quality standards for the care of people with giant cell arteritis in secondary care [8], stated that a TAB service needs to be well resourced and not dependent on a single surgeon. A robust well-developed pathway is imperative.

This training course addressed a gap in the formal teaching of TAB, which is a complex and specialised procedure. The development of a standard formal teaching curriculum would help to ensure that all trainees would finish training with the key knowledge and skills to perform a TAB and would therefore be able to provide high quality care for their patients. Surgical complications can be reduced by using a structured curricula and a multi-faceted learning approach (wet labs and simulation) as demonstrated by the modern-day approach to teaching cataract surgery [9]. A paper titled 'Temporal artery biopsy: time for a rethink on training?' by Osei et al [10] advocated for the teaching of important anatomical landmarks including identifying danger zones, the risks and benefits of the procedure and a step-by-step guide on how to perform the procedure with a supporting video. This teaching event fulfilled every single one of these desired components. The authors also ensured that McGaghie's best practice principles of simulation-based education (i.e. curriculum integration, simulation fidelity and team training) were fulfilled during our simulation-based session [11]. Additionally, collaboration across different surgical disciplines provided insight and access to for example vascular surgeons which ophthalmologists would otherwise not get exposure to. The peer learning approach deployed also helped with engagement, interaction, participation, and enjoyment.

In clinical practice the traditional teaching approach of 'see one, do one and teach one' still exists. However, in an era where simulation training is readily available (especially in developed countries) this concept of learning and teaching has become less acceptable, is regarded as un-ethical by some and concerns have been raised about patient safety [12,13]. This teaching event addresses these concerns and provides a blue-print for a repeatable and robust teaching experience for the benefit of trainees and ultimately for patients. When trainees actively participate in the learning process it enriches their personal development due to a desire and motivation to achieve [14].

Simulation training helps to achieve competency-based training goals. Early surgical exposure, technical prowess and the assimilation of skills are key aims of any simulation training. It can be used as a safe, realistic, and standardised modality to not only teach and train surgeons but to also assess their performance. Simulation training offers the opportunity to develop and nurture transferable skills into clinical practice [15]. A frequently overlooked benefit of simulation/wetlab training is that of supervisors understanding the ability of trainees prior to them stepping into theatre. This knowledge can enable trainers and trainees to map out realistic achievable goals which is important under the current format of a rotational based system. Moreover it can aid in appropriate case selection for trainees. In this context of the EyeSi surgical stimulator, which is a cataract training system, this has been shown to improve trainee confidence, reduce operating times and reduce intraoperative complications [16-20].

The key findings from this teaching event include: most trainees face difficulties with both the level of training and finding opportunities to perform TAB's at their local hospitals. Most trainees have gained poor numbers of TAB procedures performed. Generally this teaching event helped to improve the knowledge and understanding of trainees pertaining to mapping the temporal artery, using an ultrasound doppler to locate the temporal artery and performing a TAB. A lack of knowledge, a lack of procedures previously performed, concern about damaging the facial nerve and a lack of senior support/supervision were all identified as reasons as to why trainees get apprehensive when it comes to performing a TAB.

In August 2024 the Royal College of Ophthalmologists will launch their new curriculum known as 'Curriculum' 2024'. In this General Medical Council approved curriculum there will no longer be a minimum set number of TAB procedures that trainees need to perform at level 3 (the expected level of a general ophthalmologist) ophthalmology training in the UK. However being able to locate the temporal artery with an ultrasound probe, being able to perform a TAB and understanding its risk and benefits are expected standards of trainees for Oculoplastic level 4 (independent specialist) training. It is the belief of the authors that given that GCA can present with visual loss it is important for all ophthalmology trainees to know the principles of TAB and ideally be able to perform it. Moreover, in my opinion, as a current trainee (author SR), removing the cap on a minimum number of procedures needed to be performed is not a good idea. This is because a minimum requirement usually sets an initial target for trainees to aim for. Then depending on exposure, experience, motivation, and sub-specialty interest (i.e. wanting to pursue oculoplastics) trainees can set personal targets to achieve.

A particular strength of approach used was that it was designed by a current OST (author SR). He intricately understood the gaps in knowledge and poor clinical skills with respect to TAB and was keen to improve these to enable the provision of high-quality care for patients.

Limitations of this work include, despite the brilliance of the model, such models can never be a substitute for 'real' anatomy in the form of Cadavers. The authors plan on developing a hybrid model to more closely replicate 'real life' anatomy. Two areas for improvement include: 1) substituting the spongy material/core component within the suture pad as it was a little too 'bouncy'/elastic and soft, which made tissue handling and suturing a little unrealistic, and 2) the skin overlying the suture pad was not taut enough which presented challenges in creating the initial incisions with a blade.

Future goals include the creation of a formal and standardised web-based curriculum followed by further practical training with an updated version of our training models. The authors are not aware of any commercially available ready to use TAB models.

This work provides a fascinating insight into how TAB training is being delivered, the impact that it has on trainees and the potential safety issues for patients. We hope that this training event will serve as a foundation for future high quality teaching sessions for TAB.

<u>Conclusions</u>

We have developed a robust simulation model of TAB and developed this into a workshop that can be replicated by other deaneries. This could even be taught at the Royal College of Ophthalmologists' annual congress where simulation training opportunities are now being offered.

Summary Box

What was known before?

1. A TAB is an important diagnostic tool in patients suspected to have GCA.
2. Trainees largely receive informal teaching pertaining to TAB's.

What this study adds?

1. Provides a novel wet lab model, the first of its kind, that can be replicated to teach TAB.
2. The models for this workshop were bespokely designed and 70% of attendees stated that the model was realistic compared to human anatomy.
3. Insights into how TAB training is currently being delivered.
4. How formal teaching (following set objectives) of TAB's can help to improve the skills and knowledge of trainees and then ultimately improve patient care.
5. Confirms previous study findings with respect to trainee experiences (lack of confidence and lack of formal training)
6. Demonstrates the benefits of cross specialty training.
7. Fills a 'black hole' in terms of published literature pertaining to how to teach TAB.

References

[1] Mackie SL, Dejaco C, Appenzeller S, et al. British Society for Rheumatology guideline on diagnosis and treatment of giant cell arteritis: executive summary. Rheumatology (Oxford). 2020 Mar 1;59(3):487-494. Doi: 10.1093/rheumatology/kez664. PMID: 31970410.

[2] Carifio J, Perla R. Resolving the 50-year Debate Around using and Misusing Likert Scales. Med Educ. 2008;42(12):1150–1152

[3] Cohen L, Manion L, Morrison K (eds). Research Methods in Education. 6th edn. (Routledge, Taylor and Francis Group, Oxon, 2007).

[4] Galloway GD, Klebe B, Riordan-Eva P. Surgical performance for specialties undertaking temporal artery biopsies: who should perform them? Br J Ophthalmol. 2002 Feb;86(2):250. doi: 10.1136/bjo.86.2.250. PMID: 11815362; PMCID: PMC1771006.

[5] Ing EB, Wang DN, Kirubarajan A, et al. Systematic review of the yield of temporal artery biopsy for suspected giant cell arteritis. Neuroophthalmology. 2018;43(1):18-25. Doi:10.1080/01658107.2018.1474372

[6] Mollan SP, Paemeleire K, Versijpt J, et al. European Headache Federation recommendations for neurologists managing giant cell arteritis. J Headache Pain. 2020;**21**:28. Doi: 10.1186/s10194-020-01093-7

[7] Al-Mousawi AZ, Gurney SP, Lorenzi AR, et al. Reviewing the Pathophysiology Behind the Advances in the Management of Giant Cell Arteritis. Ophthalmol Ther. 2019;**8**:177–93. Doi: 10.1007/s40123-019-0171-0.

[8] Coath FL, Bukhari M, Ducker G, et al. Quality standards for the care of people with giant cell arteritis in secondary care. Rheumatology (Oxford). 2023 Sep 1;62(9):3075-3083. doi: 10.1093/rheumatology/kead025. PMID: 36692142.

[9] Rogers GM, Oetting TA, Lee AG, et al. Impact of a structured surgical curriculum on ophthalmic resident cataract surgery complication rates. J Cataract Refract Surg. 2009;**35**:1956–60. Doi: 10.1016/j.jcrs.2009.05.046.

[10] Osei G, Rainsbury P, Morris D, et al. Temporal artery biopsy: time for a rethink on training? Eye (Lond). 2023 Feb;37(3):506-510. Doi: 10.1038/s41433-022-01963-1. Epub 2022 Feb 21. PMID: 35190668; PMCID: PMC8859846.

[11] Le KDR. Principles of Effective Simulation-Based Teaching Sessions in Medical Education: A Narrative Review. Cureus. 2023 Nov 21;15(11):e49159. doi: 10.7759/cureus.49159. PMID: 38130558; PMCID: PMC10733780.

[12] Kotsis SV, Chung KC. Application of See One, Do One, Teach One Concept in Surgical Training. Plast Reconstr Surg. 2013;131:1194-201. 10.1097/PRS.0b013e318287a0b3

[13] Romero P, Gunther P, Kowalewski KF, et al. Halsted's "See One, Do One, and Teach One" versus Peyton's Four-Step Approach: A Randomized Trial for Training of Laparoscopic Suturing and Knot Tying. J Surg Educ. 2018;75:510-5. 10.1016/j.jsurg.2017.07.025

[14] Engels PT, de Gara C. Learning styles of medical students, general surgery residents, and general surgeons: implications for surgical education. BMC Med Educ. 2010;10:51. 10.1186/1472-6920-10-51

[15] Agha RA, Fowler AJ. The role and validity of surgical simulation. Int Surg. 2015 Feb;100(2):350-7. Doi: 10.9738/INTSURG-D-14-00004.1. PMID: 25692441; PMCID: PMC4337453.

[16] C Lopez-Beauchamp, GA Singh, SY Shin, at al. Surgical simulator training reduces operative times in resident surgeons learning phacoemulsification cataract surgery. Am J Ophthalmol Case Rep, 17 (2020), Article 100576

[17] JD Ferris, PH Donachie, RL Johnston, et al. Royal College of Ophthalmologists' National Ophthalmology Database study of cataract surgery: report 6. The impact of EyeSi virtual reality training on complications rates of cataract surgery performed by first and second year trainees. Br J Ophthalmol, 104 (2020), pp. 324-329

[18] PC Staropoli, NZ Gregori, AK Junk, *et al.* Surgical simulation training reduces intraoperative cataract surgery complications among residents. Simul Healthc, 13 (2018), pp. 11-15

[19] EM Feudner, C Engel, IM Neuhann, et al. Virtual reality training improves wet-lab performance of capsulorhexis: results of a randomized, controlled study. Graefes Arch Clin Exp Ophthalmol, 247 (2009), pp. 955-963

[20] MK Daly, E Gonzalez, D Siracuse-Lee, et al. Efficacy of surgical simulator training versus traditional wet-lab training on operating room performance of ophthalmology residents during the capsulorhexis in cataract surgery. J Cataract Refract Surg, 39 (2013), pp. 1734-1741

Figure Legends/Captions

Figure 1 – Images of the models used, showing the variation in depth of the frontal branch of the superficial temporal artery model**.** Model A, on the left, shows the superficial temporal artery inserted at a depth of 5mm from the surface membrane. Model B, on the right, shows the superficial temporal artery inserted at a depth of 10mm from the surface membrane.

Figure 2 – mapping the temporal artery and depiction of the danger zone.

Figure 3 – A consultant (author IW) using the ultrasound doppler device to locate the temporal artery on one of the attendees. Consent was given by the supervisors and attendees alike for their images to be used.

Figure 4 – Portrays exposed temporal arteries ready to be biopsied. (A) This was the more 'straightforward' model used as the temporal artery was inserted superficially into the model therefore making identification of it relatively easy. (B) The more complex model. The image shows the deeply situated temporal artery. Moreover marking on the model can be seen which demonstrate the path of the temporal artery and the danger zone to avoid.

Figure 5 – comparing pre and post event knowledge and understanding pertaining to mapping the temporal artery, using an ultrasound doppler to detect the TA and one's ability to perform a TAB.

Table 1 – Comparing the pre and post event results and illustrating their associated levels of statistical significance.