

## Main Article

Dr A K K Smith takes responsibility for the integrity of the content of the paper

Presented at the Coalition for Global Hearing Health Conference, 23–25 October 2016, Manila, Philippines, and at the 19th International Symposium on Recent Advances in Otitis Media, 4–8 June 2017, Gold Coast, Australia.

**Cite this article:** Smith AKK, Sokdavy T, Sothea C, Pastrana MKR, Ali RF, Huins CT, Clark MPA, Gollogly JG, Bhutta MF. Implementation and results of a surgical training programme for chronic suppurative otitis media in Cambodia. *J Laryngol Otol* 2018;**132**:711–717. <https://doi.org/10.1017/S0022215118001056>

Accepted: 12 February 2018  
First published online: 12 July 2018

**Key words:**  
Education; Global Health;  
Otologic Surgical Procedures

**Author for correspondence:**  
Dr Aaron K K Smith,  
ENT Department,  
Gold Coast University Hospital,  
1 Hospital Blvd, Southport, QLD 4215,  
Australia  
E-mail: [aaronkksmith@gmail.com](mailto:aaronkksmith@gmail.com)

# Implementation and results of a surgical training programme for chronic suppurative otitis media in Cambodia

A K K Smith<sup>1,2</sup>, T Sokdavy<sup>3</sup>, C Sothea<sup>3</sup>, M K R Pastrana<sup>4</sup>, R F Ali<sup>5</sup>, C T Huins<sup>6</sup>, M P A Clark<sup>7</sup>, J G Gollogly<sup>3</sup> and M F Bhutta<sup>3,8</sup>

<sup>1</sup>ENT Department, Gold Coast University Hospital, Southport, Queensland, Australia, <sup>2</sup>School of Medicine, Griffith University, Gold Coast, Australia, <sup>3</sup>Children's Surgical Centre, Kien Khleang Rehabilitation Centre, Phnom Penh, Cambodia, <sup>4</sup>St Luke's College of Medicine, Quezon City, Philippines, <sup>5</sup>School of Medicine, Imperial College London, UK, <sup>6</sup>ENT Department, University Hospitals, Birmingham NHS Foundation Trust, UK, <sup>7</sup>ENT Department, Gloucestershire Hospitals NHS Foundation Trust, Cheltenham, UK and <sup>8</sup>ENT Department, Brighton and Sussex University Hospitals Trust, Brighton, UK

## Abstract

**Background.** Chronic suppurative otitis media is a massive public health problem in numerous low- and middle-income countries. Unfortunately, few low- and middle-income countries can offer surgical therapy.

**Methods.** A six-month long programme in Cambodia focused on training local surgeons in type I tympanoplasty was instigated. Qualitative educational and quantitative surgical outcomes were evaluated in the 12 months following programme completion. A four-month long training programme in mastoidectomy and homograft ossiculoplasty was subsequently implemented, and the preliminary surgical and educational outcomes were reported.

**Results.** A total of 124 patients underwent tympanoplasty by the locally trained surgeons. Tympanic membrane closure at six weeks post-operation was 88.5 per cent. Pure tone audiometry at three months showed that 80.9 per cent of patients had improved hearing, with a mean gain of 17.1 dB. The trained surgeons reported high confidence in performing tympanoplasty. Early outcomes suggest the local surgeons can perform mastoidectomy and ossiculoplasty as safely as overseas-trained surgeons, with reported surgeon confidence reflecting these positive outcomes.

**Conclusion.** The training programme has demonstrated success, as measured by surgeon confidence and operative outcomes. This approach can be emulated in other settings to help combat the global burden of chronic suppurative otitis media.

## Introduction

Perforation of the tympanic membrane, with intermittent or persistent discharge from the ear, is termed chronic suppurative otitis media (CSOM). Chronic suppurative otitis media is a neglected disease, with a global prevalence estimated to be as high as 360 million, leaving up to 200 million with significant hearing impairment and a disease burden of over 2 million disability-adjusted life years.<sup>1,2</sup> The disease is associated with socio-economic deprivation, and several countries, particularly those in the Pacific region and South-East Asia, report a disease prevalence at greater than 4 per cent, reaching the World Health Organization (WHO) classification of a massive public health problem.<sup>1,2</sup>

The WHO has stipulated that programmes to tackle CSOM must incorporate primary prevention, including improvements to socioeconomic factors and medical therapies.<sup>3</sup> However, many CSOM cases will persist or recur following medical treatment, and they can then only be cured by surgical intervention. Surgical treatment of CSOM ranges in complexity depending on the disease manifestation, but for isolated mucosal disease tympanoplasty provides barrier protection against middle-ear infection, and often improves hearing, with associated gains to quality of life.<sup>1,4</sup> Chronic suppurative otitis media with cholesteatoma requires more aggressive surgical treatment to remove the cholesteatoma, and prevent potential intratemporal and extratemporal complications.<sup>5</sup> Such surgery aims to provide a safe ear by removing disease, with the secondary objectives of ensuring the ear is dry and functional through ossicular and tympanic reconstruction where possible.

Unfortunately, few low- and middle-income countries are currently equipped with the human and material resources required for a locally staffed otological surgery service. Many of the regions with the highest prevalence of CSOM paradoxically have a shortage of trained ENT surgeons, and, of these, very few are able to perform tympanoplasty or mastoidectomy.<sup>6</sup> Tympanoplasty and mastoidectomy are technically difficult procedures that require a period of sustained training and the use of specialised equipment.<sup>7</sup>

To fill the need for tympanoplasty and mastoidectomy, short term visits by ENT surgeons from high-income countries have been undertaken, with acceptable reported surgical outcomes.<sup>8–11</sup> However, these missions are limited in their duration, and do not provide the sustainability of a locally delivered service. As the surgical disease burden

in low- and middle-income countries has gained more attention, there has been a move towards building local capacity through training and task shifting to local surgeons.<sup>12,13</sup> This has included the development of long-term partnerships between hospitals from high- and low-resourced countries in which sustained general otolaryngology training and education has been established.<sup>14</sup>

The value of 'vertical' surgical missions that focus on a single pathology and its management has been well established in other surgical subspecialties. This has led to infrastructure for the management of conditions such as cleft palate and cataracts.<sup>15</sup> Whilst there has been recognition of this impetus on local training during otological surgical missions, there is a dearth of formal reporting on such training programmes or the outcomes produced.

Cambodia is a lower- to middle-income nation in a region of high CSOM prevalence.<sup>1</sup> National healthcare challenges include a predominantly rural population, a gross national income per capita of US\$ 1070 and a health expenditure being borne primarily by the patient as an out-of-pocket expense.<sup>16,17</sup> The Cambodian healthcare system is still recovering from the loss of medical expertise suffered during the Khmer Rouge regime, and, prior to our intervention, it included (to our knowledge) only one local surgeon trained in tympanoplasty.

In October 2014, we instigated a sustained in-country training programme in Cambodia to develop local proficiency in type I tympanoplasty. This study aimed to describe this novel training programme, and its qualitative educational outcomes (as determined by interviews with the two local trainees) and quantitative surgical outcomes (as determined by surgical closure of the tympanic membrane and improvement to hearing). A subsequent four-month long training programme in mastoidectomy and ossiculoplasty was implemented, and we report the preliminary surgical and educational outcomes from this.

## Materials and methods

### Study design and setting

The Institutional Review Board of the Children's Surgical Centre reviewed and approved this study. The tympanoplasty training programme was instigated in October 2014 at the Children's Surgical Centre, a multidisciplinary surgical charity hospital in Phnom Penh.<sup>18</sup> The Children's Surgical Centre provides free rehabilitative surgery to the impoverished population of Cambodia, attracting many patients from rural communities beyond Phnom Penh. The patient population suffering from CSOM have a wide age range and advanced disease profile (Table 1).

Prior to our intervention, the Children's Surgical Centre had an ENT department staffed by locally trained nurses and two Cambodian ENT surgeons. The two surgeons had completed medical degrees and post-graduate otolaryngology residency programmes within Cambodia, but this included very limited exposure to otological surgery given the inaccessibility of necessary material resources and local expertise. They had experience of observing and assisting in tympanoplasty and mastoidectomy, but neither individual had previously performed the procedures as the primary surgeon.

### Tympanoplasty training programme

An initial scouting visit by a UK-trained ENT consultant determined equipment and training needs. This was followed

**Table 1.** Patients' demographics and clinical parameters used to assess tympanoplasty outcome

Variable	Value
Sex (n (%))	
- Male	37 (29.8)
- Female	87 (70.2)
Age (years)	
- Mean (SD)	26.0 (11.0)
- Range	10-58
Ear affected (n (%))	
- Left	68 (54.8)
- Right	56 (45.2)
HIV status (n (%))	
- Known HIV+	13 (10.5)
- Known HIV- or status unknown	111 (89.5)
Presence of middle-ear inflammation (n (%))	
- Visibly inflamed middle-ear cavity	83 (66.9)
- No inflammation visible	41 (33.1)
Presence of contralateral middle-ear disease (n (%))	
- Evidence of contralateral disease	70 (56.5)
- No evidence of contralateral disease	54 (43.5)
Pre-operative perforation (n (%))	
- ≥61% perforation	37 (29.8)
- 31-60% perforation	66 (53.2)
- ≤30% perforation	21 (16.9)

SD = standard deviation; HIV = human immunodeficiency virus

by procurement, from UK and US suppliers, of a surgical microscope (with a teaching side arm) and microsurgical instruments, and transportation of these to Cambodia. Equipment and transportation costs were subsidised by donations from medical supply companies and UK hospital foundations where possible, with the remaining costs remunerated by the Children's Surgical Centre directly.

A training fellow (CTH) delivered six-month continuous in-country training in type I tympanoplasty to the two local ENT surgeons. The training fellow (CTH) is a UK-qualified ENT surgeon who at that time had just completed his training. A UK operating theatre nurse accompanied the training fellow for the first two weeks of his residency, providing parallel training to the local operating theatre nurses.

Training for the surgeons included themes of applied surgical anatomy, clinical judgment in peri-operative disease recognition and management, microsurgical technique, and intra-operative judgment and problem solving. Training was provided via traditional formats such as didactic lectures and paper-based resources, as well as online resources and model trainers for practical skill exercises.<sup>19</sup> Trainees were allowed to perform relevant stages of tympanoplasty as soon as deemed appropriate (Fig. 1).

In order to facilitate learning, we utilised a standardised technique with general anaesthetic, using a post-auricular approach, an underlay composite tragal cartilage and perichondrium graft, an anterior tuck where required (for anteriorly based perforations), underlay and overlay gelatine packing to support the graft, and a head bandage. The post-auricular



**Fig. 1.** One of the Cambodian surgeons being trained by author MFB.

approach and composite graft were deemed appropriate methods for the typically large perforations and disease severity found in our population, although other approaches and graft materials were also discussed and taught (Table 2). All tympanoplasties performed during and subsequent to the training programme were performed with consent obtained by the local Khmer speaking surgeons.

By the end of the six-month training period, the Cambodian surgeons were performing tympanoplasty as the primary surgeon. They had the option of contacting their trainer in the UK via internet or phone if any concerns or queries arose.

### **Mastoidectomy training programme**

After completion of the tympanoplasty training programme, another otology fellow (MFB) provided four months' continuous in-country training in mastoidectomy and homograft ossiculoplasty for the treatment of cholesteatoma (Fig. 1). This built upon the themes and surgical skills focused on during the tympanoplasty training programme, with more detail on temporal bone anatomy and surgical drilling skills.

Pettigrew plastic temporal bones were used as an aid to teaching.<sup>20</sup> Again, a standardised operative technique was utilised, with a post-auricular incision, a 'front to back' canal wall down approach to minimise risk of residual or recurrent disease (follow up of our patient population was not assured), lowering of the facial ridge, and meatoplasty where required. Surgery could comprise atticotomy, atticantrostomy or mastoidectomy, depending upon extent of disease.

We did not routinely utilise pre-operative computed tomography scanning. Facial nerve monitoring was not available.

If ossiculoplasty was deemed appropriate, it was performed simultaneously (again in light of the uncertainty of follow up,

**Table 2.** Surgical parameters used to assess tympanoplasty outcome

Variable	n (%)
Surgical approach	
– Post-auricular	113 (91.1)
– Transcanal	6 (4.8)
– Endaural	5 (4.0)
Graft material	
– Temporalis fascia	18 (14.5)
– Cartilage-perichondrium composite	80 (64.5)
– Perichondrium	26 (21.0)
Anterior tuck on graft placement	
– Yes	108 (87.1)
– No	15 (12.1)
– Not recorded	1 (0.8)

with potentially no opportunity for staged surgery). Where a stapes was present and the reconstructed middle-ear cavity was low in depth, a cartilage cap was placed on the stapes capitulum; otherwise, the incus was refashioned for use as a replacement ossicle, or a strut of bone carved from the calvarium in cases where the incus was eroded.

### **Educational outcomes evaluation**

Learner outcomes were assessed one year after the tympanoplasty training programme and again one year after the mastoidectomy training programme. Using a five-point Likert scale, the trainees were asked to rate their surgical confidence and ability in various aspects of performing tympanoplasty, mastoidectomy and homograft ossiculoplasty; they were asked to rate these parameters prior to the onset of the training programme and at the present time.

A researcher who had no role in training (author RFA) conducted private semi-structured interviews with the two trainee surgeons, to gather their opinions on the structure of the training programme and on personal learning outcomes. Interviews were conducted in English (a second language for our trainee surgeons). These interviews were audio recorded and transcribed, and the results were evaluated using thematic analysis.

### **Clinical outcomes evaluation**

We retrospectively evaluated the clinical outcomes of all type I tympanoplasties, performed by the trainee surgeons, for a period of 12 months after the resident trainer (CTH) departed (March 2015 to March 2016). These operations were performed independently of the trainer. We included patients with a chronically discharging perforation and excluded those with cholesteatoma.

We collected data on patient demographics and surgical pathology. Surgical success was measured by evidence of an intact tympanic membrane on otoendoscopy at six weeks' follow up (we lost a large proportion of patients to follow up after six weeks, making analysis at later time points unreliable).

We evaluated audiological outcomes using pure tone audiometry performed by a partner organisation (All Ears Cambodia), comparing audiometric thresholds pre-operatively

**Table 3.** Self-rated confidence in performing tympanoplasty\*

Question	Mean score prior to training	Mean score after training
I understand the indications & contraindications for surgical intervention	5	5
I am confident in interpretation of pre- & post-operative investigation	2.5	5
I am confident in setup & operation of surgical microscope	2.5	5
I am confident in surgical approach & lifting of tympanomeatal flap	1.5	5
I am confident in graft harvesting	3	5
I am confident in graft placement	2	5
I am confident I can perform tympanoplasty in timely manner	1	4
I am confident in my ability to perform tympanoplasty independently & without supervision	1	5

The scale scores ranged from 1 (not confident) to 5 (very confident). \*As rated by the two trained surgeons

and at three months post-operatively. Our primary audiological outcome was change in the air-bone gap.

We also evaluated all mastoidectomies performed for cholesteatoma, with or without ossiculoplasty, from January 2016 to July 2017, where the primary surgeon was one of the Cambodian trainees (the mastoidectomy training programme ran from January to June 2016). We assessed tympanic membrane closure, the proportion of cases with a dry ear, time to dry ear, and audiological results (assessed as described previously). Survival analysis was carried out for the time until dry ear, with patients lost to follow up censored at day 0, and those who never achieved a dry ear censored at the last day of recorded follow up. In order to create a comparison group, we performed the same analysis of outcomes from mastoidectomies conducted from November 2014 to July 2017 where the primary surgeon was non-Cambodian (foreign).

## Results

### Educational outcomes

At completion of the tympanoplasty training period, the more senior of the Cambodian trainees felt able (and was deemed able) to perform type I tympanoplasty without supervision. The junior trainee, with the supervision of her senior local colleague, reached the same stage only two months later.

In the interviews conducted one year after completion of the tympanoplasty training programme, the trainees confirmed confidence in their ability to perform the steps of type I tympanoplasty, stating: 'Confidence in performing tympanoplasty is 100 per cent' and '100 per cent all cases no problem'.

Both trainees were deemed safe to perform mastoidectomy after completion of the mastoidectomy training programme.

Interviews revealed that the trainees preferred prolonged training with a single resident teaching fellow over the previous experience of multiple short-term visits by visiting surgeons, with the trainees stating: 'when we start the first time we cannot want more teacher, only the one', 'I know the

**Table 4.** Self-rated confidence in performing mastoidectomy\*

Question	Mean score prior to training	Mean score after training
I understand the indications & contraindications for mastoidectomy	4	4.5
I am confident in setup & operation of surgical microscope & mastoid drills	2.5	4.5
I am confident in surgical approach & lifting of post-auricular subcutaneous flap	4	4.5
I am confident in temporal bone anatomy, including identification of important surgical landmarks (e.g. tegmen, sigmoid sinus, lateral semi-circular canal, facial nerve, ossicles)	2	4
I am confident in deciding extent of dissection required in mastoidectomy depending on intra-operative findings	2	4
I am confident in my ability to perform homograft ossiculoplasty	2.5	4.5
I am confident in refashioning & reconstructing cavity, including lowering facial ridge & placing fascial grafts	1	4
I am confident in performing meatoplasty	1	4
I am confident in my ability to recognise & manage potential complications encountered during mastoidectomy, such as lateral canal fistula or dehiscent facial nerve	1	4.5
I am confident in my ability to perform mastoidectomy independently & without supervision	1	4

The scale scores ranged from 1 (not confident) to 5 (very confident). \*As rated by the two trained surgeons

person in the short term, but sometimes I cannot show myself and what I can do. In the long term I can do or if I have a problem I can ask' and 'One week is a very short time, I had the experience already I didn't get anything'.

The programme also succeeded in delivering analytical skills. The trainees stated: 'I learnt from the international surgeon, we need to think not just about us, we need to think about the patient, about what is good for the patient', 'they make me to think, they teach me to think' and 'when we have problem during the operation we find by our self'.

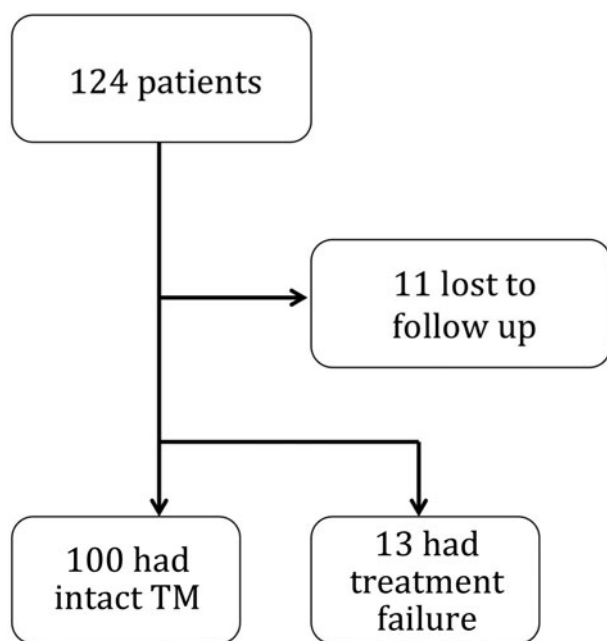
The Likert scale evaluation of confidence and ability in tympanoplasty revealed that both Cambodian surgeons had an increase in surgical confidence across all aspects questioned (Table 3). The mean improvement across all aspects was 2.35 points, and their overall confidence to perform the operation independently improved by 4 points (out of a possible 4).

A similar increase in surgical confidence was witnessed after the mastoidectomy training programme (Table 4). The mean improvement across all aspects assessed was 2.28 points, and the overall confidence to perform mastoidectomy independently improved by 3 points (out of a possible 4).

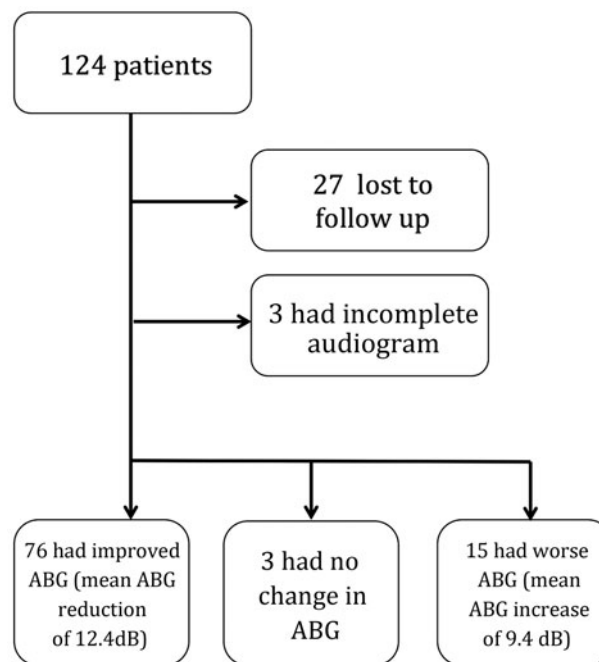
**Table 5.** Mastoidectomy outcomes at three months\*

Outcome	Patients operated on by Cambodian surgeons	Patients operated on by foreign surgeons	P-value
Intact tympanic membrane (n (%))	31/35 (88)	49/56 (88)	0.87 (chi-square)
Dry ear (3 months) (n (%))	30/35 (85)	54/56 (96)	0.06 (chi-square)
Mean time to dry ear (in days)	71.1 (n = 30)	89.2 (n = 54)	0.18 (log-rank test)
Mean change in ABG (in dB)	4.8 (n = 24)	3.1 (n = 39)	0.69 (t-test)

\*For patients operated on by Cambodian and foreign surgeons. ABG = air–bone gap



**Fig. 2.** Surgical outcomes in patients undergoing tympanoplasty in the year after completion of the training programme. TM = tympanic membrane



**Fig. 3.** Audiological outcomes in patients undergoing tympanoplasty in the year after completion of the training programme. ABG = air–bone gap

**Tympanoplasty clinical outcomes**

There were 124 patients in the evaluation period (demographic characteristics are summarised in Table 1). Of these, 11 patients (8.9 per cent) were lost to follow up at the six-week review. Of the remaining 113 patients, 100 (88.5 per cent) were found to have an intact tympanic membrane, 11 (9.7 per cent) had a residual perforation estimated at less than 5 per cent and 2 (1.8 per cent) had a residual perforation of undocumented size (Fig. 2).

Post-operative audiometry data were available in 94 patients, with 27 (21.8 per cent) lost to follow up and a further 3 patients excluded because of incomplete audiograms. Across the 94 patients, there was a mean reduction in air–bone gap of 12.4 dB (range, –32.5 to 43.8 dB). There were 76 patients (80.9 per cent) who had audiometric improvement (mean reduction in air–bone gap of 17.1 dB), 3 who had no change in air–bone gap and 15 with an increased air–bone gap (mean increase in air–bone gap of 9.4 dB) (Fig. 3). Those patients with a residual perforation had a mean reduction in air–bone gap of 15.1 dB. The average post-operative air–bone gap was 19.5 dB, with 84 patients (89.4 per cent) having a post-operative air–bone gap of 30 dB or lower.

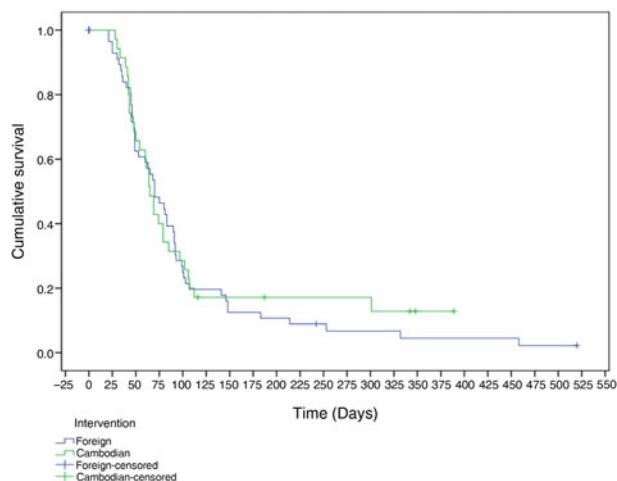
There were no major complications such as complete sensorineural hearing loss, facial nerve palsy, vertigo or death.

**Mastoidectomy clinical outcomes**

A total of 112 mastoidectomies were performed at the Children’s Surgical Centre in the evaluation period; 66 (58.9 per cent) were primarily performed by overseas-trained surgeons and 46 (41.1 per cent) were carried out by Cambodian surgeons. Ninety-one patients (81 per cent) attended for clinical follow up at three months; 63 patients (56 per cent) underwent a hearing test, with the remainder lost to follow up.

There were no significant differences between operation outcomes for Cambodian versus foreign surgeons in terms of rates of tympanic membrane closure, the proportion of cases with a dry ear or the time taken to achieve a dry ear (Table 5, and Figs. 4 and 5). There was no significant mean change in audiological thresholds in either group (Table 5); however, using the classification of 15 dB change in air–bone gap as a clinically significant change in hearing, five patients operated on by Cambodian surgeons had improved hearing and two patients had worse hearing. The equivalent figures for patients operated on by foreign surgeons were nine with improved hearing and three with worse hearing.

There were no major complications in either group, such as complete sensorineural hearing loss, cerebrospinal fluid leak, persistent vertigo or facial paralysis.



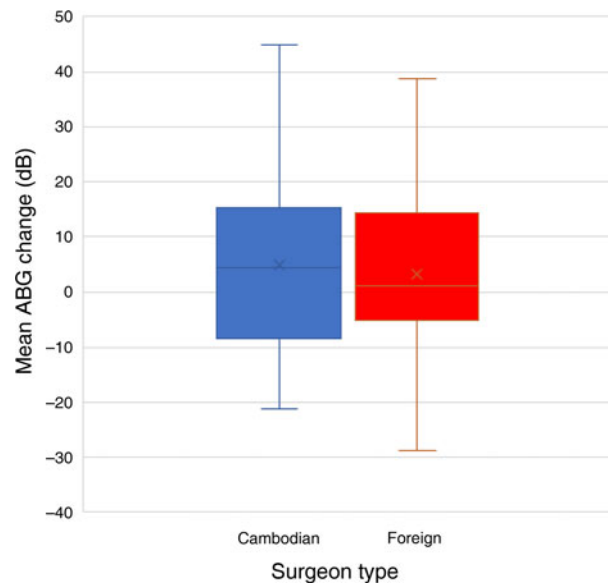
**Fig. 4.** Time to dry ear in patients undergoing mastoidectomy by Cambodian and foreign surgeons.

## Discussion

This is the first report from a resource-limited setting demonstrating successful outcomes from a training programme in tympanoplasty and mastoidectomy. We attribute our success to the provision of training fellows who were resident in-country for four to six months, and so were able to provide a sustained period of training. Other authors have recognised the importance of training local surgeons in tympanoplasty in resource-limited settings, and have conducted such training during short-term surgical missions, but have not reported or demonstrated educational benefits from their efforts.<sup>21–23</sup>

Our training programme resulted in excellent educational and clinical outcomes. In interviews, the two Cambodian surgeons reported a strong preference for having a resident fellow (over and above short-term visits) to meet their training needs. They also reported marked improvements in all aspects of their assessment, surgical technique and decision-making in the care of patients with CSOM, as evidenced through their comments in the semi-structured interview and in their self-assessment surveys. We acknowledge that these qualitative outcomes were assessed retrospectively, with no baseline data obtained at initiation of either training programme, increasing the risk of recall bias. We also acknowledge that the trainees self-reported ‘100 per cent’ confidence may reflect a lack of experience of the difficulties in some cases of tympanoplasty, although, to date, the trainee surgeons have not felt the need to abandon a case.

The clinical outcomes are also commendable. The results from the first year in which our surgeons were performing tympanoplasty independently show an 88.5 per cent success rate in tympanic membrane closure. The WHO regards a successful tympanoplasty programme as one where success rates are over 80 per cent.<sup>3</sup> Studies from high-income countries report rates of 80–85 per cent, with similar results reported by surgeons performing otological missions in resource-limited environments.<sup>9–11,24</sup> One limitation of our study is that evaluation of the tympanic membrane was conducted at six weeks after the operation, which may over-estimate success. Late failure is known to occur, but could not be assessed here as few of our patients attended for long-term follow up. This logistical difficulty is well recognised, with our study



**Fig. 5.** Mean change in air-bone gap (ABG) in patients operated on primarily by Cambodian and foreign surgeons. The whiskers indicate the minimum and maximum mean air-bone gap change; the boxes represent the first and third quartiles of the mean air-bone gap change; the horizontal line within each box indicates the median air-bone gap change; and the cross within each box represents the mean air-bone gap change across the study population.

displaying a relatively low loss to follow up in comparison to other studies in similar settings.<sup>8–11,21–23</sup>

The audiological outcomes demonstrated a modest improvement in the majority of tympanoplasty cases, with a mean reduction in air-bone gap across all cases of 12.4 dB. This too is comparable to reports from local and visiting surgeons in other low- and middle-income countries.<sup>9–11,25,26</sup> Again, a limitation of our study is that we evaluated audiological outcomes at three months post-operatively because obtaining long-term audiological data was logistically problematic. Even at three months, there was significant loss to follow up (21.8 per cent), which, whilst somewhat less than that seen in other similar studies, could limit the validity of the audiological outcomes reported.

Early outcomes from the mastoidectomy and ossiculoplasty training programme are also encouraging, suggesting non-inferiority of the Cambodian trainees in comparison to the overseas-trained surgeons. The foreign and Cambodian surgeons had similar success in achieving a dry ear, and no difference in audiological outcomes. There are some limitations to this analysis. Operations by foreign surgeons occurred predominantly early in the evaluation period, allowing a longer period of follow up, which potentially increases rates of dry ear because of the late resolution of otorrhoea. Conversely, cases predicted to be more complex had surgery delayed until foreign expertise was available, which may bias foreign surgeon results to worse outcomes. We also recognise that this dataset is small, making it underpowered to detect small differences between the two groups of surgeons.

A notable feature of this training programme is its demonstrable sustainability. The surgeons who were trained have now been performing tympanoplasty independently for over two years, and have been undertaking mastoidectomy and ossiculoplasty for over one year. The volume of cases being referred to them has increased as their reputation has become known. A new Cambodian surgeon joined the ENT department a year ago, and is now performing

tympanoplasty solo, having been trained by the local team. We expect that in the future many more ENT surgeons will be trained in tympanoplasty and mastoidectomy by the team at the Children's Surgical Centre hospital, helping to expand the ENT skill base and provision of surgical therapy in Cambodia. The important measures in the evaluation of any surgical initiative in a low- or middle-income country are intermediate and long-term success and sustainability, and here we have strong indicators that our programme has been successful.<sup>27</sup>

There are some potential limitations to the generalisability of our programme. Tympanoplasty requires the use of a microscope and specialised micro-instruments, which may be difficult to source, and may require periodic repair or replacement. Repair can be difficult in low- and middle-income countries, where biomedical engineering departments are scarce. Equipment can be sourced through donations direct from manufacturers, as used equipment from healthcare providers in high-income settings or through e-commerce retailers. However, consumable costs in performing tympanoplasty are minimal. The specialised nature of a type I tympanoplasty training programme also necessitates sound background otolaryngology knowledge and surgical skills in the prospective trainees, which in the programme reported here was met through the training of surgeons with previous formal ENT training. For this training to be emulated successfully in other low- and middle-income countries, trainees may need similar background knowledge.

- Chronic suppurative otitis media affects up to 360 million people globally, and is associated with socioeconomic deprivation
- Tympanoplasty or mastoidectomy are often required for cure, but are not readily available in many low- and middle-income countries
- This paper describes a tympanoplasty and mastoidectomy training programme in Cambodia
- Success was demonstrated through learning outcomes of locally trained surgeons, with surgical cure rates comparable to that of foreign surgeons
- The programme is sustainable, with the trained surgeons now training others; this model can be emulated in other settings

In summary, our training programme has produced demonstrably self-confident and technically able surgeons in Cambodia, who are capable of successfully performing tympanoplasty and mastoidectomy. We believe that this model can be emulated to develop the infrastructure and capacity for the surgical therapy of CSOM in other resource-limited settings.

**Acknowledgements.** We would like to acknowledge All Ears Cambodia for their provision of pure tone audiometry for many of the patients in this study. We thank Ana Santos for her provision of operating theatre nurse training to the ENT department. We also thank the staff of the Children's Surgical Centre for welcoming us to work with them. The training programme was funded by general charitable donations to the Children's Surgical Centre from several philanthropic sources.

**Competing interests.** None declared

## References

- 1 Acuin J. *Chronic Suppurative Otitis Media: Burden of Illness and Management Options*. Geneva: World Health Organization, 2004
- 2 Monasta L, Ronfani L, Marchetti F, Montico M, Brumatti LV, Bavar A *et al*. Burden of disease caused by otitis media: systematic review and global estimates. *PLoS One* 2012;**7**:e36226
- 3 World Health Organization. *Prevention of Hearing Impairment from Chronic Otitis Media*. Geneva: World Health Organization, 1996
- 4 Jung KH, Cho YS, Hong SH, Chung WH, Lee GJ, Hong SD. Quality-of-life assessment after primary and revision ear surgery using the chronic ear survey. *Arch Otolaryngol Head Neck Surg* 2010;**136**:358–65
- 5 Bhutta MF, Williamson IG, Sudhoff HH. Cholesteatoma. *BMJ* 2011;**342**:d1088
- 6 Unit for Prevention of Blindness and Deafness. *Multi-country Assessment of National Capacity to Provide Hearing Care*. Geneva: World Health Organization, 2013
- 7 Palva T, Ramsay H. Myringoplasty and tympanoplasty--results related to training and experience. *Clin Otolaryngol Allied Sci* 1995;**20**:329–35
- 8 Barrs DM, Muller SP, Worrndell DB, Weidmann EW. Results of a humanitarian otologic and audiology project performed outside of the United States: lessons learned from the "Oye, Amigos!" project. *Otolaryngol Head Neck Surg* 2000;**123**:722–7
- 9 Horlbeck D, Boston M, Balough B, Sierra B, Saenz G, Heinichen J *et al*. Humanitarian otologic missions: long-term surgical results. *Otolaryngol Head Neck Surg* 2009;**140**:559–65
- 10 Isaacson G, Melaku A. Results of pediatric tympanoplasty on short-term surgical missions. *Laryngoscope* 2015;**126**:1464–9
- 11 Lehnerdt G, van Delden A, Lautermann J. Management of an "Ear Camp" for children in Namibia. *Int J Pediatr Otorhinolaryngol* 2005;**69**:663–8
- 12 Riviello R, Ozgediz D, Hsia RY, Azzie G, Newton M, Tarpley J. Role of collaborative academic partnerships in surgical training, education, and provision. *World J Surg* 2010;**34**:459–65
- 13 Aliu O, Pannucci CJ, Chung KC. Qualitative analysis of the perspectives of volunteer reconstructive surgeons on participation in task-shifting programs for surgical-capacity building in low-resource countries. *World J Surg* 2013;**37**:481–7
- 14 Waller B, Larsen-Reindorf R, Duah M, Opoku-Buabeng J, Edwards BM, Brown D *et al*. Otolaryngology outreach to Komfo Anokye Teaching Hospital: a medical and educational partnership. *J Laryngol Otol* 2017;**131**:608–13
- 15 Farmer PE, Kim JY. Surgery and global health: a view from beyond the OR. *World J Surg* 2008;**32**:533–6
- 16 UNDP in Cambodia. In: <http://www.kh.undp.org/content/cambodia/en/home.html> [1 June 2018]
- 17 The World Bank. World Development Indicators. In: <https://data.worldbank.org/products/wdi> [1 June 2018]
- 18 Children's Surgical Centre. In: <http://www.csc.org/> [6 November 2016]
- 19 Clark MP, Westerberg BD, Mitchell JE. Development and validation of a low-cost microsurgery Ear Trainer for low-resource settings. *J Laryngol Otol* 2016;**130**:954–61
- 20 Bhutta MF. A review of simulation platforms in surgery of the temporal bone. *Clin Otolaryngol* 2016;**41**:539–45
- 21 Isaacson G. Framework for advancing otolaryngology: head and neck surgery in Ethiopia. *Otolaryngol Head Neck Surg* 2014;**151**:634–7
- 22 Redleaf HH, Mihretu DY, Tulu T. Ethiopian surgical camps a win for surgeons and patients. *Hear J* 2016;**69**:24–6
- 23 Isaacson G, Drum ET, Cohen MS. Surgical missions to developing countries: ethical conflicts. *Otolaryngol Head Neck Surg* 2010;**143**:476–9
- 24 Hardman J, Muzaffar J, Nankivell P, Coulson C. Tympanoplasty for chronic tympanic membrane perforation in children: systematic review and meta-analysis. *Otol Neurotol* 2015;**36**:796–804
- 25 Kamath MP, Sreedharan S, Rao AR, Raj V, Raju K. Success of myringoplasty: our experience. *Indian J Otolaryngol Head Neck Surg* 2013;**65**:358–62
- 26 Mishra P, Sonkhya N, Mathur N. Prospective study of 100 cases of underlay tympanoplasty with superiorly based circumferential flap for subtotal perforations. *Indian J Otolaryngol Head Neck Surg* 2007;**59**:225–8
- 27 Ibrahim GM, Cadotte DW, Bernstein M. A framework for the monitoring and evaluation of international surgical initiatives in low- and middle-income countries. *PLoS One* 2015;**10**:e0120368