Original Article

Cataract surgery in mobile eye surgical unit: Safe and viable alternative

Rajesh Pioneer Sangameswaran, Gajendra Kumar Verma, Narayanan Raghavan, Jayaraj Joseph[1], Mohanasankar Sivaprakasam[1]

Aim: The aim of this study was to evaluate the utility and safety of a mobile eye surgical unit (MESU) in providing quality cataract surgery for the indigent rural population with poor access to quality eye care. **Materials and Methods:** Two buses connected by a vestibule were built to meet the requirements for a self-sufficient operation theater (OT). In every camp, safe transportation of units, good alignment of buses, safe water, and maintenance of sterile environment were achieved with optimal utilization of OT. **Results:** Two thousand and twenty-one patients in 21 remote locations underwent cataract surgery in MESU between 2012 and 2015. Visual outcome was 6/9 or better in 79.3%, posterior capsular rupture in 0.91%, zonulardialysis in 0.3%, aphakia in 0.2%, iridodialysis in 0.2%, and there was no incidence of endophthalmitis. **Conclusion:** MESU is a safe alternative in combating preventable blindness due to cataract in far-off villages and tribal areas by providing quality eye care at the patient's doorstep. This model has a great potential for duplication in other parts of India.

Key words: Cataract surgery, mobile eye surgical unit, preparatory vehicle, surgery vehicle

Access this article online

Website: www.ijo.in

DOI: 10.4103/0301-4738.195599

Quick Response Code:

Cataract has been reported to be responsible for 50%–80% of bilaterally blind in the country.[1] The model of screening camps to identify cataract and carrying out the cataract surgeries at the base hospitals has been the backbone of combating avoidable blindness in India.[2] Providing quality eye care services closer to them would need large infrastructure investments with limited utilization of facilities in smaller communities. As an operational pilot project, a "mobile eye surgical unit" (MESU) was built for providing quality cataract surgical services at the community level in South India.

Materials and Methods

The MESU presents an innovative solution to accessibility by providing a stable, self-sufficient mobile platform that guarantees a controlled and sterile environment for performing cataract surgery in rural locations with no basic amenities.

The MESU, as illustrated in Fig. 1, consists of a set of two custom-built vehicles as follows:

- Preparatory vehicle: Houses a preoperative room with a couch to administer anesthesia and changing room
- Surgery vehicle: That houses a scrubbing station, operation theater (OT) with an operating microscope, phaco machine, electrocardiogram monitor with defibrillator, oxygen concentrator and sterilization room with tabletop autoclave machine, ETO sealer machine, and fogging machine.

To minimize the risk, initial surgeries were carried out on the premises of the base hospital. Mock trials without patients were carried out to optimize patient flow and ensure that surgeons and theater personnel were comfortable with the environment. Once these were optimized, off-site surgeries were started.

Camps were organized at particular location following a request from a nongovernmental organization. Permission for the camp was sought from the District Blindness Control Society (DBCS) for the notified period. Awareness meetings and group discussions were held with the help of local authorities for smooth conduct of the camp.

The MESU was functional from January 2012 for conducting cataract surgeries at various places in Tamil Nadu. MESU was started with many challenges such as high capital cost, the running cost, feasibility, and safety of a new system. Permission from the DBCS was given for the first 500 surgeries to know about safety and feasibility, which was renewed after 18 months by the DBCS after evaluating the safety and the feasibility.

Level grounds in schools or community halls were chosen for parking the MESU unit. The outpatient screening is set up nearby in a fixed facility such as a hall or schoolroom near the site. The equipment required for outpatient examination were transported in a separate vehicle which is used for the transportation of team members.

For every patient, demographic details, ophthalmic and medical history, blood pressure (BP) recording, random blood

Sankara Nethralaya Medical Research Foundation, [1]Department of Electrical Engineering, Healthcare Technology Innovation Center, A Joint Initiative of IIT Madras and Department of Biotechnology, Ministry of Science and Technology, Chennai, Tamil Nadu, India

Correspondence to: Dr. Rajesh Pioneer Sangameswaran, Sankara Nethralaya Medical Research Foundation, No. 18, College Road, Chennai - 600 006, Tamil Nadu, India. E-mail: drrps@snmail.org

Manuscript received: 01.03.16; Revision accepted: 16.10.16

Cite this article as: Sangameswaran RP, Verma GK, Raghavan N, Joseph J, Sivaprakasam M. Cataract surgery in mobile eye surgical unit: Safe and viable alternative. Indian J Ophthalmol 2016;64:835-9.

sugar, hemoglobin estimation by copper sulfate method, and physical examination were done. Preoperative visual acuity, slit-lamp findings, lens status, applanation tonometry, and fundus evaluation were carried out. Regurgitation on pressure on lacrimal sac area and digital biometry were performed. All patients received preoperative antibiotics for 1 day, and povidone-iodine 5% was applied 10 min before the surgery. Surgeries have been performed by four surgeons so far by a single surgeon in a day. Phacoemulsification, manual small incision cataract surgery (SICS), and extracapsular cataract extraction were performed under local anesthesia, monitoring vital parameters. Postoperatively, the patients' eyes were patched. On the first postoperative day, all patients' vision was recorded with pin hole, and a slit-lamp examination was done.

A team consisting of ophthalmologist, optometrist, and ophthalmic assistant visited the site after 1 week and 1 month postoperatively. Visual acuity with pin hole, handheld slit-lamp examination, refraction and fundus evaluation were done, and glasses were dispensed at a later date.

Results

Of the 2021 patients operated in MESU, 937 (46.4%) were males and 1084 (53.6%) were females; the mean age (standard deviation) was 61.36 ± 9.313 as shown in Fig. 2, and 107 patients (5.29%) did not come for the final follow-up.

Phacoemulsification was performed for 146 (7.2%) patients, manual SICS for 1849 (91.5%), and extracapsular cataract extraction for 26 (1.3%) patients. All patients received single-piece polymethyl methacrylate intraocular lens (IOL). Nearly 119 (5.5%) patients had diabetes, 159 (7.9%) were hypertensive, 102 (5%) had diabetes and were hypertensive, and the remaining 1617 (80%) were without systemic illness.

The present study showed a low percentage of good outcome [Table 1] at presentation based on the World Health Organization (WHO) definitions - visual acuity >20/60 was seen in 85 patients (4.1%) and 1218 patients (60.4%) had visual acuity <6/60.[3,4] Poor vision was seen more in females may be due to their traditional inaccessibility to health-care system.

The surgery was uneventful in 1988 (98.9%) patients. Posterior capsular rupture was noted in 18 patients (0.9%), zonular dialysis in 7 (0.3%), iridodialysis in 5 (0.2%), whole bag removal in 2 (0.1%), and partial Descemet's membrane detachment in three patients (0.14).[5-7] Totally 2010 patients received posterior chamber IOLs, 6 (0.25%) patients received anterior chamber IOL, s and 5 (0.2%) patients were aphakic. The postoperative complication rates were lower compared to a similar study though the sample size reported was smaller (209 patients) than the present study.[8]

Automated anterior vitrectomy was performed in eyes that had a vitreous loss. The complication rates were low compared to various studies as surgeries were done by experienced surgeons and rigid adherence to protocol for infection control and sterility.

Visual acuity <6/60 in 19 (0.93%) patients [Table 2] was due to high myopia with chorioretinal degeneration, pigmentary alteration at fovea, retinitis pigmentosa, and Stargardt disease. One hundred and seven (5.29%) patients were lost to follow-up at the final visit.

There were two untoward incidents noted among 2021 surgeries. The first case, a 49-year-old female with no systemic illness, developed hypotension with BP of 97/42 mmHg for

Table 1: Preoperative visual acuity

Presenting visual acuity	Male *n* (%) age *N*=937	Female *n* (%) age *N*=1084	*P*
<6/18	47 (2.3%)	38 (1.8%)	0.1563
>6/18<6/60	339 (16%)	369 (18.2%)	0.9471
6/60 or worse	551 (27%)	677 (33.4%)	0.0008
Total	937 (46.4%)	1084 (53.6%)	0.106

Table 2: Postcataract surgery final visual outcome

Presenting visual acuity	Male *n* (%) age *N*=882	Female *n* (%) age *N*=1032	*P*
6/9 or better	748 (37%)	855 (42.3%)	0.247
6/18 to 6/12	108 (5.34%)	151 (7.47%)	0.1281
6/24 to 6/36	16 (0.79%)	17 (0.84%)	0.7799
6/60 or worse	10 (0.49%)	9 (0.44%)	0.5649
Total	882 (43.88%)	1032 (51%)	0.453

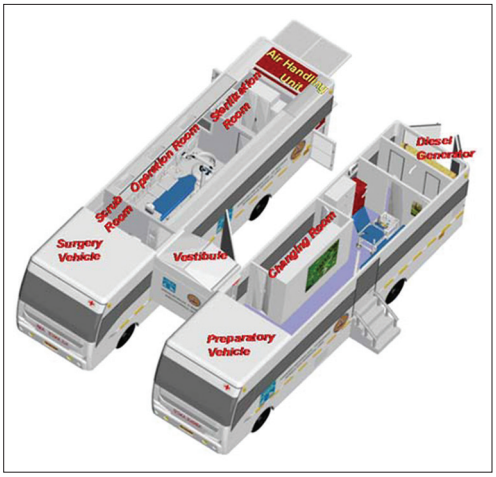

Figure 1: Layout of the mobile eye surgical unit

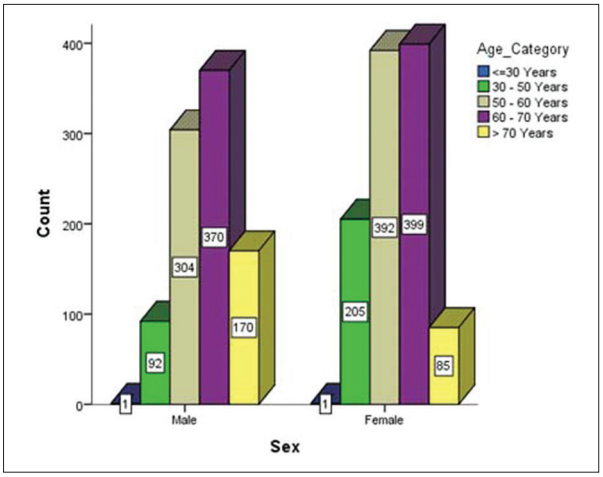

Figure 2: Age and sex distribution

5 min after peribulbar block with 2% lignocaine. She was conscious, alert, and well oriented with no neurological deficit; saturation was 100%, so she was kept under observation. The patient's BP stabilized to 120/74 mmHg over the next 45 min and underwent uneventful SICS + IOL.

In the second instance, a 67-year-old female on treatment for diabetes and hypertensive developed breathlessness with orthopnea during surgery with signs of pulmonary edema. Surgery was abandoned after cortical aspiration. On examination, the following findings were noted: Pulse, 118/min; respiratory rate, 32/min; BP, 230/138 mmHg; PO_2, 78%; and the patient was unresponsive, with tongue falling back and had basal crepitation and rhonchi. She was managed medically and BP brought down to 180/110 mmHg, saturations increased to 99%, wheeze and rhonchi decreased, and became conscious oriented and comfortable in 30 min. She was shifted to Intensive Care Unit in district headquarters hospital 45 km away in an ambulance for further evaluation and management and was discharged the following day after 24 h of observation. Cortical wash with secondary IOL implantation was done in the base hospital after 3 weeks under anesthetic care.

It was notable that there was no incidence of endophthalmitis among the patients who underwent cataract surgery in MESU.[9] The present study is underpowered to report the endophthalmitis rate with the small sample size of 2021.

Discussion

The MESU was developed on two separate standard bus chassis (Ashok Leyland 222 Viking) so as to enable them to travel independently to access remote villages. They are connected on-site by a detachable double-walled interconnecting vestibule to make a single compact surgical unit.

The MESU was lifted off its wheels through independently controllable hydraulic cylinders to ensure stability during surgeries. Locally available electrical power was supplemented by an onboard 20 kVA diesel generator supported by a 5 kVA uninterrupted power supply unit. The sterility of the OT was maintained by air handling unit that filters particles >0.3 micron and by providing positive pressure (3–5 Pa). The entry to the surgery area was through twin air curtains, isolating the sterile environment thereby preventing contamination. The OT interior was made of stainless steel to enable effective cleaning. Clean water was obtained from an on-board reverse osmosis plant. The modular nature of the system with adequate storage space for the consumables ensures fast repair and update of the subsystems with minimal operational downtime and low maintenance cost.

The capital cost for the unit was 3 crores which includes the vehicle, fabrication, and the equipment cost. Being a pilot project, per surgery cost varies depending on the number of surgeries conducted per camp from Rs. 7185 for 100 surgeries to Rs. 4790 for 150 surgeries [Table 3]. All efforts are continuing to bring down the cost without compromising the quality by increasing the number of surgeries per camp.[10]

The team consisting of operating surgeon (2), trainee ophthalmologist (2), optometrist, camp administrator, OT technicians (4), outpatient staff (4), and electrical

Table 3: Mobile eye surgical unit camp statistics

No of camps	Mesu camp details				No of working days
	Date	Area	Total screening	No of surgery in MESU	
1	15-3 Jan'12	SN-Chennai	MESU CAMP PT	35	13
2	19-11 Feb'12	Pernambut-VEL (D)	298	154	24
3	21-17 Mar'12	Jollarpet-VEL (D)	310	291	26
4	02-08 Feb'13	Arunachalaeswara Ashramam-TVM (D)	172	52	7
5	22-29 Apr '13	Chunampet-KPM (D)	181	26	8
6	11-12 May'13	Selaiyur-KPM (D)	269	14	2
7	27-03 Feb'14	Vettavalam-TVM (D)	435	43	8
8	05-14 Feb'14	Udayarpalayam-(ARI)	494	93	10
9	22-06 Mar'14	Jollarpet-VEL (D)	690	116	12
10	19-29 May'14	Alangayam-VEL (D)	526	53	10
11	29-09 Jul'14	Periyamuthur-KRI (D)	821	104	11
12	20-28 Aug'14	Kalpakkam-KPM (D)	672	80	9
13	21-27 Sep'14	Vellimalai-Vizhupuram (D)	99	28	7
14	7-15 Dec'14	Ettayapuram-Thuthu (D)	409	49	11
15	15-24 Feb'15	Thirurani-TVR (D)	796	153	11
16	06-15 Mar'15	Mahendra City-KPM (D)	476	66	10
17	03-12 Arp'15	Sullurpet-AP (D)	596	115	10
18	18-28 Apr''15	Kalpakkam-KPM (D)	1280	154	10
19	05-15 Jun'15	Orikkai -KPM (D)	773	158	11
20	05-14 Sep'15	SHAR ISRO	606	120	10
21	23-1 Nov'15	Azhinjiwakkam	625	117	10
		Total	10528	2021	

maintenance staff (2) was identified and trained during the trial phase.

For safe surgical environment, washing and disinfecting of OT was done for 3 consecutive days along with culture by settle plate method and air sampling.[11,12] Surgeries were started only after obtaining negative culture for 3 consecutive days.

At the end of each surgery, used articles were removed from the theater, instruments were sent for cleaning and sterilization, disposable items and the theater wastes were disposed as per the protocol. The theater was disinfected with bactericidal solution and reset. Cleaning and fogging was done after the last surgery every day.

After the pilot phase of the first 500 surgeries, duration of each camp was planned for 10 days, starting with patient selection for the first 3 days during which time OT was made ready [Table 4]. The surgeries were planned for 5–6 days depending on the number of patients selected. Single surgeon available on-site performed all the surgeries. All surgeries were done free of cost, the tubings and phaco probes were changed for each case, all consumables were disposed after each surgery, and disposable drapes were used. After understanding the logistics, 25 surgeries per day can be done safely by an experienced surgeon in the MESU in spite of no availability of anesthetist and vitreoretinal surgeon in camp site.

Various studies have noted that people readily do not accept eye care surgeries when offered free of cost. The common barriers for cataract surgeries encountered were attitudinal barriers related to service delivery, cost, and affordability. The attitudinal barriers were could manage daily work (71%), cataract not mature (68%), could see clearly with other eye (64%), too busy (57%), female gender (37%), fear for surgery (34%) or death (13%), old age (33%), and worry about cost of surgery (27%).

Table 4: Costing of the mobile eye surgical unit camp

Estimated Mobile surgical Unit Expenses/camp		
Number of Cataract Surgeries to be Performed		100
Variable Cost per surgery	Amount in(Rs.)	
Drugs	1157	
Food	70	
IOL	160	
Dark Glass	138	
Total Variable Cost for 100 surgeries	1525	152500
Fixed Cost		
Establishment Cost& Camp Allowance		204000
Vehicles running cost		35000
Repairs & Maintenance		10000
Total Fixed Cost		249000
Other Cost incurred by SN for 11 days camp		
Accommodation for 11 days for the Team		150000
Food expenses for 11 days for the Team		110000
Shamiana/Chairs/Table/side wall/floor mat, 10 days rental		25000
Auto announcement+Pamphlets distribution 2 day's		15000
Miscellaneous expenses		15000
Local channel advertisement charges 11 days		2000
Total Other Cost incurred by SN for 11 days camp		317000
Total Cost per camp		718500

The barriers relating to service delivery, cost, and affordability included insufficient family income (76%), not knowing anybody who had undergone cataract surgery (26%), no one to accompany (20%), and inaccessibility (20%).[13] Accessibility is as important as the need for health care.[14] Lack of an attendant was relevant in a rural setup mainly due to transportation cost, loss of labor during hospital stay, and the miscellaneous expense for the attendant.[15,16] Fear as a barrier is not without reason, especially for illiterate in rural areas, fear of hospital, surgery, and its consequences is natural.[17] MESU provides accessibility that addresses the concerns of rural illiterates to avail the services without fear and undue expenses.

The WHO has provided guidelines for cataract surgery outcomes –85% should have visual acuity of 20/60 or better, 10% must have <20/60–20/200, and 5% should have visual acuity of <20/200.[18,19] In the present study, postoperatively, 1862 patients (92.11%) had best-corrected visual acuity above the visual acuity of 6/18 which was comparable to other studies at 94% or 89.8%.[20-22] The visual recovery in patients who had undergone surgery in MESU is comparable with other reports from India. MESU provides an alternative to the base hospital approach by giving the same standard eye care in a peripheral eye camp in rural and remote areas.[23]

The ophthalmologists are trained in basic and advanced life support and are trained with physicians and anesthetists for careful selection of patients to identify any warning sign and to manage acute emergencies if needed. The OT is equipped with emergency medicines, endotracheal tube with laryngoscope, and ambu bag. A vehicle is kept ready during the time of surgeries, preferable an ambulance, if available for shifting the patient. Intrathecal/vascular spread of local anesthetic may have caused the hypotension.[24,25] Bupivacaine has not been used for cataract surgery in MESU due to its longer duration of action and intense toxicity.

Conclusion

MESU is a safe and useful alternative in combating preventable blindness due to cataract in far-off villages and tribal areas by providing quality eye care at the patients' doorsteps and to those who are inaccessible for quality eye care. The results suggest that performing cataract surgeries in a mobile bus under all asepsis is indeed a viable complimentary method to achieve the singular objective of combating blindness in the underprivileged population. This model has a great potential of duplication in other parts of India. Careful selection of the team, strict adherence to protocol, and averaging above 25 surgeries per day to decrease per surgery cost will allow MESU a safe and viable alternative in community eye care.

Financial support and sponsorship

Nil.

Conflicts of interest

There are no conflicts of interest.

References

1. Murthy G, Gupta SK, John N, Vashist P. Current status of cataract blindness and vision 2020: The right to sight initiative in India. Indian J Ophthalmol 2008;56:489-94.
2. Chandrashekhar TS, Bhat HV, Pai RP, Nair SK. Coverage, utilization and barriers to cataract surgical services in rural South India: Results from a population-based study. Public Health 2007;121:130-6.
3. Resnikoff S, Pascolini D, Etya'ale D, Kocur I, Pararajasegaram R, Pokharel GP, *et al.* Global data on visual impairment in the year 2002. Bull World Health Organ 2004;82:844-51.
4. Gogate PM. Small incision cataract surgery: Complications and mini-review. Indian J Ophthalmol 2009;57:45-9.
5. Murthy GV, Vashist P, John N, Pokharel G, Ellwein LB. Prevalence and vision-related outcomes of cataract surgery in Gujarat, India. Ophthalmic Epidemiol 2009;16:400-9.
6. Jaffe MS, Jaffe GE. Cataract Surgery and its Complications. Vol. 6. St. Luis: Mosby; 1997. p. 248-9.
7. Kothari M, Thomas R, Parikh R, Braganza A, Kuriakose T, Muliyil J. The incidence of vitreous loss and visual outcome in patients undergoing cataract surgery in a teaching hospital. Indian J Ophthalmol 2003;51:45-52.
8. Sheck L, Riley A, Wilson GA. Is a mobile surgical bus a safe setting for cataract surgery? A four-year retrospective study of intraoperative complications. Clin Exp Ophthalmol R Aust N Z Coll Ophthalmol 2011;330-1.
9. Thomas R. Reducing endophthalmitis in India: An example of the importance of critical appraisal. Indian J Ophthalmol 2010;58:560-2.
10. Hutton DW, Le HG, Aravind S, Ravindran RD, Aravind H, Ravilla T, et al. The cost of cataract surgery at Aravind Eye Hospital, India. Invest Ophthalmol Vis Sci ARVO Annual Meeting Abstract 2014;55:1289.
11. Prathab AG, Lalitha C. Microbial surveillance of air quality in operation theatre. Comparison of conventional settleplate technique versus use of air sampling device. J Eval Med Dent Sci 2012.
12. Napoli C, Marcotrigiano V, Montagna MT. Air sampling procedures to evaluate microbial contamination: A comparison between active and passive method in operation theatres. BMC Public Health 2012;12:594.
13. Dhaliwal U, Gupta SK. Barriers to the uptake of Cataract surgery in patients presenting to a hospital. Indian J Ophthalmol 2007;55:133-6.
14. Rao GN, Khanna RC, Athota SM, Rajshekar V, Rani PK. Integrated model of primary and secondary eye care for underserved rural areas: The L V Prasad Eye Institute experience. Indian J Ophthalmol 2012;60:396-400.
15. Rabiu MM. Cataract blindness and barriers to uptake of cataract surgery in a rural community of Northern Nigeria. Br J Ophthalmol 2001;85:776-80.
16. Ubah JN, Isawumi MA, Adeoti C. Barriers to uptake of cataract surgery: An eye camp account. Res Ophthalmol 2013;2:1-3.
17. Guruprasad BS, Datti NP, Krishnamurthy D, Ranganath BG, Shamanna BR, Sangeetha T. Barriers to the uptake of cataract surgery in a rural population of south Karnataka, India. Int J Curr Res Rev 2013;5:77-82.
18. Vijaya L, George R, Rashima A, Raju P, Arvind H, Baskaran M, *et al.* Outcomes of cataract surgery in a rural and urban south Indian population. Indian J Ophthalmol 2010;58:223-8.
19. World Health Organization. Informal Consultation on Analysis of Blindness Prevention Outcome. WHO/PBL/98.68. Geneva: World Health Organization; 1998.
20. Venkatesh R, Muralikrishnan R, Balent LC, Prakash SK, Prajna NV. Outcomes of high volume cataract surgeries in a developing country. Br J Ophthalmol 2005;89:1079-83.
21. Gogate PM, Deshpande M, Wormald RP, Deshpande R, Kulkarni SR. Extracapsular cataract surgery compared with manual small incision cataract surgery in community eye care setting in western India: A randomised controlled trial. Br J Ophthalmol 2003;87:667-72.
22. Limburg H, Foster A, Vaidyanathan K, Murthy GV. Monitoring visual outcome of cataract surgery in India. Bull World Health Organ 1999;77:455-60.
23. Gogate P, Kulkarni AN. Comparison of cataract surgery in a base hospital and in peripheral eye camps. Community Eye Health 2002;15:26-7.
24. Brookshire GL, Gleitsmann KY, Schenk EC. Life-threatening complication of retrobulbar block. A hypothesis. Ophthalmology 1986;93:1476-8.
25. Javitt JC, Addiego R, Friedberg HL, Libonati MM, Leahy JJ. Brain stem anesthesia after retrobulbar block. Ophthalmology 1987;94:718-24.