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Economic cost savings with the use of total body phototherapy for the treatment of severe neonatal jaundice in Nigeria

Abstract

Kernicterus and severe jaundice are major contributors to neonatal morbidity in Nigeria, and they are commonly treated using invasive exchange blood transfusion (EBT) techniques. Total body phototherapy exposure (TBPE) is a new technique that avoids the risks of EBT and has been shown to be effective. The aim of this study was to evaluate the typical economic savings that result from the clinical success of the TBPE as provided by the Firefly® system in a Nigerian new-born centre. Severely jaundiced neonates who were treated using EBT between January 2017 and December 2017 were assessed as control cases. These neonates were compared to neonates who received TBPE using the Firefly® system (MTTS Asia, Hanoi Vietnam) as a first course intervention (test cases) after February 2018 onward. A total of 82 severely jaundiced new-borns qualified for inclusion, including 19 control cases and 63 test cases. All TBPE cases were successfully discharged, but two mortalities relating to EBT complications were recorded. The mean direct cost of treatment per patient was ₦94,553 (US$262) in the control group and ₦18,897 (US$52) in the test group. The mean patient burdens for other parameters (control: test) were bacterial infection burden (100% : 11%), human labour man-hours (9.8 : 1.2), and blood contamination burden (25% : 3%). The huge relative amount of savings recorded in this study has clearly demonstrated that Firefly® TBPE is an application that is both affordable and effective in a resource-constrained setting. Hence, we recommend its use in low- and middle-income countries.

Keywords: jaundice, phototherapy, firefly®, exchange transfusion, neonates

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Abbreviations

EBT, exchange blood transfusion; TBPE, total body exposure technique; TSB, total serum bilirubin; SB, serum bilirubin; NNJ, neonatal jaundice; SCBU, special care baby unit; LMIC, low and middle-income countries

Introduction

Recent publications from Myanmar, Vietnam and Nigeria have demonstrated the effectiveness of a double-sided phototherapy irradiation for the treatment of severe neonatal hyperbilirubinemia.[1–3] Kernicterus and related conditions, which result from severe neonatal jaundice, have continued to be major contributors to neonatal morbidity in Nigeria, and are still widely treated using conventional overhead phototherapy and invasive exchange blood transfusion (EBT) techniques across the country.[4–7] Total body phototherapy exposure (TBPE) of the neonate during treatment—as made possible by the bi-directional ray delivery (from top and bottom)—is a relatively new application in Nigeria which has been achieved with the use of the Firefly® system (MTTS Asia, Hanoi, Vietnam) in several centres.[3] The invasive EBT technique is associated with many risks and burdens, including the possibility of bacterial infection, plasmodium parasite contamination of transfused blood, or outright mortality following on from procedural complications. Nigerian centres often resort to the practice of initiating prophylactic antibiotics and malaria treatment in some cases judged to be at high-risk of these complications. In addition, EBT is perceived to be time-consuming in terms of the human labour required to carry out the procedure. It is also perceived to be expensive in terms of the cost of the consumables and kits required for the intervention.

Tertiary hospitals in Nigeria are burdened with poor funding and are often faced with the need to ensure that practice techniques are not only effective, but also cost-saving. Therefore, the assessment of the economic costs associated with the equally effective EBT and TBPE is essential so that informed management decisions can be made during procurement. Conventional florescent tube phototherapy and EBT remained the standard interventions at the SCBU of Alex-Ekweme Federal University Teaching Hospital (AFUTH) Abakaliki Nigeria, until February 2018 when the TBPE technique was introduced. The aim of this study was to comparatively evaluate the typical economic savings as a result of the clinical success of TBPE using the Firefly® phototherapy system in a busy Nigerian new-born centre.

Material and methods

Severely jaundiced neonates normally indicated for treatment using EBT were recruited into the study. All documented cases who received EBT between January 2017 and December 2017 were retrieved and evaluated as the control cases (CC). Similarly, severely jaundiced neonates who received TBPE (after February 2018) using the Firefly® bi-directional phototherapy system (MTTS Asia; Figure 1) as the first course of intervention were retrieved and evaluated as test cases (TC). The threshold for the determination of severe jaundice was set at a serum bilirubin (SB) level of 10 mg/dL (171 µmol/L) for neonates weighing below 2000 g at birth or born earlier than 35 weeks of gestation, whereas 12.5 mg/dL (213.8 µmol/L) was set for those with a birth weight (BW)≥2000 g or GA≥35 weeks, based on Nigerian standard practice, as described in the literature.[3] All cases extracted from the files were examined and non-qualifying cases were excluded based on the criteria of SB, BW, and GA. Length of hospital admission (in days) owing to severe jaundice was calculated based

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on the lowering of the SB below the indicated threshold in each case. The direct costs of interventions provided in the course of treatment were noted in each case, and quantified using a standard cost of EBT kit and the procedural consumables valued at ₦74,587.50 (Table 1) for patients who received EBT. The standard power consumption of the Firefly® per unit of electricity was ₦30.93 per KWh chargeable by the Enugu Electricity Distribution Company of Nigeria (EEDC) over the period of treatment in each case. The Firefly® voltage rating (60W, 100-240VAC, 47/63Hz) was applied to the following calculation:



Figure 1 Firefly® total body irradiation phototherapy system.

Photograph reproduced with official permission from: MTTS Asia, Hanoi, Vietnam. The system delivers phototherapy irradiation to neonates in both directions, above and below.

Table 1 Cost Breakdown for EBT at AFUTH Abakaliki Nigeria

S/N	ITEMS	COST (₦)
1	Grouping and cross matching of one pint of blood for the procedure	4000
2	One pint of blood used for the procedure	7000
3	Nasogastric for umbilical catheterization	300
4	EBT procedure	7000
5	Calcium gluconate	500
6	Intravenous giving set	150
7	10% dextrose water	300
8	Intravenous cannula	200
9	Promethazine drug	50
10	Hydrocortisone drug	200
11	Intravenous ceftazidime	1200
12	Intravenous sultamicillin	1700
13	Soluset	1300
14	Normal saline	300
		24,200
15	Cost of EBT set	50,387.50
Total cost		74,587.50

AFUTH, Alex-Ekweme Federal University Teaching Hospital; EBT, exchange blood transfusion

Hourly operating cost at EEDC rate = 30.93 x 60 / 1000 = ₦1.86/hour.

By AFUTH hospital management standards, the cost of the Firefly® device and its maintenance was set for recovery over 8 years at a projected total patient turnover of 300 neonates over this period. This translates to a one-off charge of ₦1,060,000 /300= ₦3,530 per patient. Therefore, the cost of Firefly® usage was given by:

F(₦) =1.86 x duration (hr) + 3,530

Administrative charges owing to length of hospital stay were quantified in each case based on the hospital standard rate Table 2 and given by:

A(₦) =2,500 x stay (days) + 1200 x maintenance (weeks) + 2,250

Therefore, total charge for CC patients who received EBT treatment was given by:

$$CC\ (₦) = A + 74{,}587.50$$

And for TC patients who received TBPE, this was given by:

$$TC\ (₦) = A + F$$

or TC (₦) = A + F + 74,587.50 (where EBT was also given)

Table 2 Admission and Administrative Charges as AFUTH Abakaliki (₦)

S/N	ITEMS	COST (₦)
1	Admission fee	1000
2	Nursing care	2,500 x days (d)
3	Doctor's service	750
4	Service charge	500
5	Maintenance fee	1200 x weeks (w)
Total cost		2500.d + 1200.w + 2250

Incidences of other associated morbidities or burdens resulting from EBT or TBPE were also noted. These include: (i) plasmodium contaminated blood transfusion evidenced by post-procedure fever and subsequent anti-malarial medication recorded, (ii) indication of infection burden evidenced from antibiotic treatment following EBT, (iii) any skin burns or rashes owing to TBPE, and (iv) outright mortality directly linked to EBT or TBPE complications. The total human labour input as measured in 'man-hours' required in the delivery of each application for each case was quantified. The average EBT human labour was measured at 75 minutes during each procedure by three members of staff and at least 3 hours of subsequent close monitoring by one doctor and one nurse. This translates to a total of 9.75 man-hours for each EBT intervention. The Firefly® was set up in an average of 6 minutes or 0.1 man-hours by a single member of staff. All the six economic burdens were applied to all patients in both the 'CC' and 'TC' groups, quantifying the resulting parameters of mean, median, and range. Ethical approval for this study was provided by the research ethics committee of Alex-Ekwueme Federal University Teaching Hospital Abakaliki Nigeria.

Results

A total of 82 severely jaundiced new-borns qualified for inclusion comprised 19 control cases and 63 test cases. Most of the retrieved files in the control group were disqualified for inclusion owing to poor

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documentation and insufficient data entry for proper assessment, as set out in the protocol for this study. All TBPE cases were successfully discharged, but two mortalities relating to EBT complications were recorded from the control group. The mean direct cost of treatment per patient was ₦94,553 (US$262) in the control group and ₦18,897 (US$52) in the test group. The burden of bacterial infection was evidenced in 100% of the neonates in the control group and 11% of the neonates in the test group. The mean burden of human labour required for a patient was 9.8 man-hours in the control group and 1.2 man-hours in the test group. The economic burden of intervention against plasmodium blood contamination was evidenced in 25% neonates in the control group and 3% in the test group. The quantifiable economic savings through use of Firefly® TBPE as the first course of treatment in the test group is summarized in Table 3. There was no record of skin burns or rashes in TBPE patients.

Table 3 Comparative cost burdens of intervention techniques and economic savings

		CONTROL cases (EBT)	TEST cases (TBPE + EBT)	Economic savings of TC against CC per patient (₦)	Annual average saving over 32 patients (₦)
	Mean	93,553	18,785		
Direct treatment cost (₦)	Median	93,038	9,506	75,656	2,420,992
	Range	81,538–112,737	7,004–96,594		
In-direct costs					
	Mean	9.75	1.2		
Labour (man-hour)	Median	9	0.1	8.55	273.6
	Range	9.0–10.5	0.1–9.9		
Blood contamination rate (%)		25	3	-	22% more freed
Bacterial infection rate (%)		100	11	-	89% freed
Outright mortality (number)		2	0	-	>2 extra saved

EBT, exchange blood transfusion; TBPE, total body phototherapy exposure; TC, test cases; CC, control cases

Discussion

The present study has demonstrated that total body phototherapy exposure of neonates during the treatment of severe neonatal jaundice using the Firefly® system is very efficient and a good non-invasive alternative to EBT intervention. This is consistent with already published research.[1–3] The adoption of retrospective data in this investigation has enabled an unbiased assessment of the often-neglected indirect economic costs that ensure the effectiveness of long existing clinical procedures in the Nigerian healthcare system. The control cases extracted for assessment were included based on patient files that provided enough of the required information, as more patients presented with severe neonatal jaundice in 2017 than the analysed 19 cases in this study. Record keeping was much better from January 2018. This led to the 63 patients included from February 2018 after the management of AFUTH introduced the Firefly® system as the first course of treatment for this condition. The inclusion of infection-related drugs alongside the direct cost was justifiable as these medications form part of the EBT treatment protocol to combat possible bacterial infection and transfusion reaction. Expenditure associated with these drugs is made whether or not the medication is eventually used post-procedure. The burden of blood contamination and bacterial infection recorded in the test group came from the few patients who received EBT in addition to the initial TBPE as there was no record of this burden emanating from TBPE intervention on its own.

The present study set out to investigate the accuracy of the decision of the AFUTH management in opting for the Firefly® TBPE based on the resulting economic indices, which are often neglected during decision-making in a typical busy Nigerian tertiary centre. Our findings have confirmed the clinical effectiveness of TBPE as all the patients who received the intervention were discharged successfully. Beyond this, our comparative results also show that the hospital achieved a huge amount of economic savings that could have been easily overlooked if not for this study. Applying a modest estimation of 32 patients presenting annually at the very busy AFUTH SCBU, this study has projected a huge direct treatment cost saving of ₦2,420,992 (about US$6,678.59) per annum, amongst others (Table 3). The annual labour savings of 273.6 man-hours is huge. At the official employment standards of eight working hours per day and 21 working days per month, this labour saving translates to 1.7 months of a senior staff salary, monetarily estimated to be ₦852,857 (US$2,353) without allowances.[8]

Conclusion

The Nigerian healthcare system is laboured with all kinds of imported medical devices and a range of outdated procedures, such that it is often difficult for the management of tertiary hospitals to decide the best applications to apply or switch over to. Our study has shown compelling evidence that Firefly® TBPE delivers better clinical and economic value to neonates, and in fact, hospital management in resource-constrained settings (Figure 2). However, the adoption of this technique in Nigeria and elsewhere is currently very slow, perhaps owing to lack of concise economic analyses of other benefits associated with Firefly® TBPE prior to this study. The poor record keeping of AFUTH SCBU especially before 2018 posed a limitation to this study leading to fewer qualifying cases for inclusion. Unannounced mains power failures at the hospital facility was a frequent experience and limitation that might have adversely affected the accuracy of overall time of treatment for neonates who received

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TBPE. Further study would assess improvements based on a more recent Firefly® model which has been designed with inbuilt power backup battery. The huge relative amount of savings recorded in this study has clearly demonstrated that Firefly® TBPE is an application that is both affordable and effective for a resource-constrained setting. Hence, we recommended the use of Firefly® TBPE in low- and middle-income countries of the world.

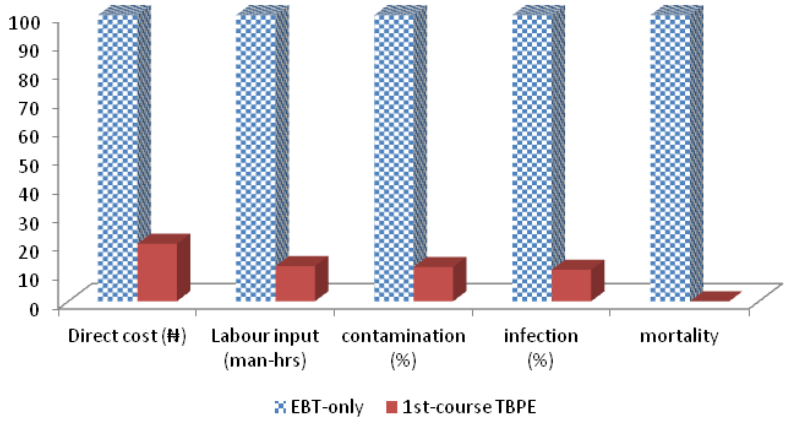


Figure 2 Relative costs and burdens of TBPE as first course treatment compared to EBT-only.

TBPE, Total body phototherapy exposure; EBT, exchange blood transfusion.

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Conflicts of interest

The authors of this paper declare no conflicts of interest associated with the research and publication of this article.

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