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IN VITRO EFFICACY MEASUREMENTS OF LED-BASED PHOTOTHERAPY DEVICES COMPARED TO TRADITIONAL LIGHT SOURCES IN A MODEL SYSTEM**Hendrik J. Vreman¹, Ronald J. Wong¹, Jamie R. Murdock², David K. Stevenson¹**¹Department of Pediatrics, Stanford University School of Medicine, Stanford, CA²Natus Medical, San Carlos, CA

Phototherapy (PT) using blue light (400–525nm) is standard treatment for hyperbilirubinemia in newborns and Crigler-Najjar (CN) patients.^{1,2} Traditional PT devices are based on broad wavelength band fluorescent (Fluor) or halogen (Hal) light sources. Recently, high intensity light emitting diodes (LEDs) have become available.³ These small, versatile, energy efficient, solid state light sources emit high intensity blue light in the narrow wavelength band of 455–475nm, centered within the bilirubin (BR) light absorption range. Our laboratory has developed several LED-based PT devices,^{4,5} including a portable device (PortaBed) for the treatment of CN patients.⁶ The neoBLUE™ LED Phototherapy device (Natus Medical Inc.) is the first commercially available LED-based device. Our objective was to develop an *in vitro* method for determining the efficacy of PT devices to photodegrade BR, and then use the method to determine the efficacy of LED devices relative to that of traditionally-used PT light sources, accounting for the effective treatable body surface area (BSA) and mean irradiance deliverable to the exposed BSA by a device to approximate and predict potential clinical efficacy.

In vitro photodegradation of 25 μ L of 20.6mg BR and 4.0g human serum albumin/dL 0.1M KPO4 buffer, pH 7.4, contained in microhematocrit tubes, was determined by exposing horizontally-placed tubes on a heated (37°C), non-reflective, black aluminum block to the light sources at manufacturers' recommended distance for up to 60 min. After exposure, BR concentrations were quantitated with the Grof diazo method (Sigma Chemical Co., St. Louis MO), expressed as % of the dark control to determine the time (min) needed to decrease the BR concentration to 50% ($t_{1/2}$) was calculated. Tubes (n=3) were exposed to each device at an irradiance that represented the measured mean irradiance to which a preterm or term infant would be exposed to by the device. The *in vitro* measurements were then adjusted for the % treatable BSA to yield the normalized efficacy. Irradiance was measured with the Ohmeda BiliBlanket Meter II (range 400–525nm, peak 450nm) as μ W/cm²/nm. The results are as follows:

	PortaBed (Stanford)	neoBLUE (Natus)	BiliBed (Medela)	BiliLite (BB) (Olympic)	MiniBili (Ohmeda)	BiliBlanket (Ohmeda)	Wallaby Jr. (Respironics)
	Blue LEDs	Blue LEDs	Fluor	Fluor	Hal	Hal/Fiber	Hal
Distance (cm)	10	30	5	45	45	Contact	Contact
Max Irradiance	76	37	63	22	19	35	35
Pre-(Term) $t_{1/2}$	16 (16)	24 (24)	18 (18)	35 (35)	31 (40)	24 (24)	24 (24)
Pre-term $t_{1/2}$, normalized	16	24	19	35	40	60	72
Term $t_{1/2}$, normalized	16	24	25	35	74	100	126

Grouping by normalized $t_{1/2}$ values, PT devices have high (≤ 35 min) or low efficacy (> 35 min). The high efficacy group contains the newer LED-based and the traditional fluorescent light devices with blue bulbs only. All Hal-based light sources are of low efficacy.

We conclude that although the maximum irradiance levels vary widely between PT devices, the normalized $t_{1/2}$ values for preterm and term neonates show that irradiance is not the primary factor

that determines efficacy. The quality of the light, size of the subject, mean irradiance of the treatable BSA, and % treatable BSA, are all important factors that determine the potential efficacy of a device.

References

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