# Effect of phototherapy on the plasma bilirubin concentration of newborn foals

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BILIRUBIN excretion is inefficient in neonatal mammals because the hepatic conjugating system and biliary excretion are still immature (Cashore 2004). This leads to neonates undergoing different degrees of physiological hyperbilirubinaemia (Johnson and others 2002).

Persistent severe neonatal hyperbilirubinaemia may result in kernicterus, with permanent neurological damage (Ip and others 2004), due to the high affinity of bilirubin for nerve cells (Cashore 2004) and the underdeveloped blood-brain barrier (Wennberg 2000). Clinical symptoms of kernicterus are consistent with lesions primarily involving the cerebellum, the globus pallidus and the subthalamic auditory, vestibular and occulomotor nuclei (Wennberg 2000, Shapiro 2003, 2005).

Neonatal hyperbilirubinaemia is poorly diagnosed and studied in animals, including newborn foals, despite the presence of conditions such as neonatal isoerythrolysis, peripartum asphyxia syndrome and equine herpervirus-1, which cause hyperbilirubinaemia jaundice. Clinical management of hyperbilirubinaemia is particularly important in foals, because resulting nervous damage may affect their future athletic performance.

Phototherapy using blue fluorescent lamps has been shown to be an important therapeutic tool for decreasing blood bilirubin in neonatal infants (Ennever 2004). Light transforms the bilirubin molecule, making it less toxic, oxidizes the molecule facilitating excretion, and changes the molecular form to polar isomers, which can be eliminated by bile and urine without going through metabolic conversions to glucuronic compounds in the liver (McDonagh 1985, Ennever 2004).

Considering the beneficial effect of phototherapy in hyperbilirubinaemic babies (Ennever 2004), along with the fact that light crosses animal skin (Parraguez and others 1998), and the recent diagnosis of kernicterus in neonatal foals (Loynachan and others 2007), this work describes the effect of phototherapy on plasma bilirubin concentrations in newborn foals.

Eight neonatal thoroughbred foals, from normal pregnancies and parturitions, were studied. In order to diminish eventual seasonal and environmental effects, the animals used were those born in the second week of September on the San Pablo Farm (in the Maule Region of Central Chile, in the Southern Hemisphere). Four foals were exposed to phototherapy from 36 to 168 hours after birth. For this purpose, a phototherapy corral (160 x 110 x 120 cm) was built of wood in the corner of a 3 x 3 m stall (Fig 1a). Twelve 1 m long blue light fluorescent tubes (40 W) were installed inside the corral. Tubes and electrical installations were properly covered and secured to protect the foals and mares. Each foal was kept in the phototherapy corral day and night (Fig 1b), while the mother remained in the same stall. Every two hours, the foals were allowed out in order to nurse for 30 minutes (Fig 1c). The other four foals were not treated and remained in stalls with their mothers.

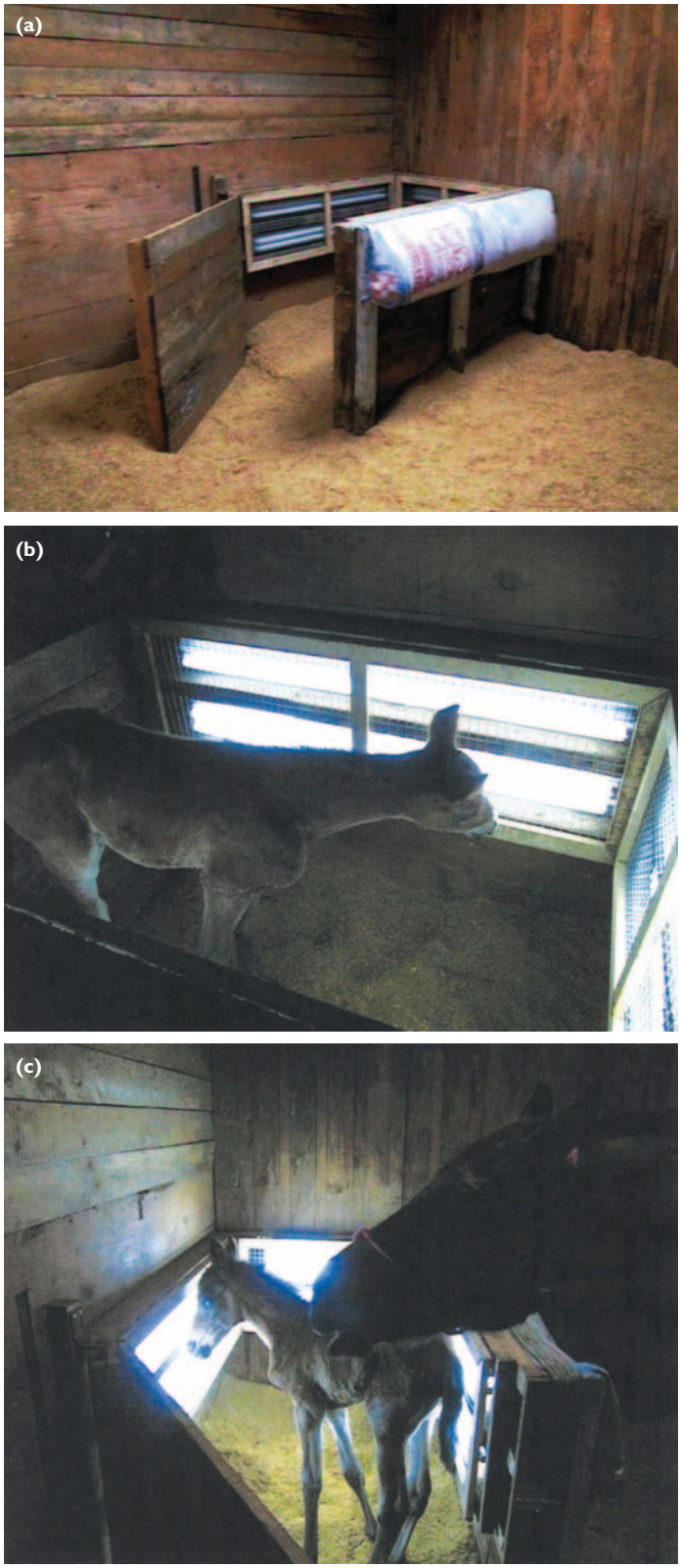


**FIG 1: (a) Location of the phototherapy corral within the stall, (b) a foal inside the phototherapy corral, and (c) a foal returning to the phototherapy corral after a period of suckling**

Blood samples (3 ml) were collected from the foals' jugular veins with heparinised syringes every 12 hours, from parturition until a week of age. From every sample, an aliquot was taken and the haematocrit measured. The remaining blood was centrifuged at 800 *g* for 10 minutes. Plasma was stored at –18°C in light-protected tubes until assayed for total (TB)

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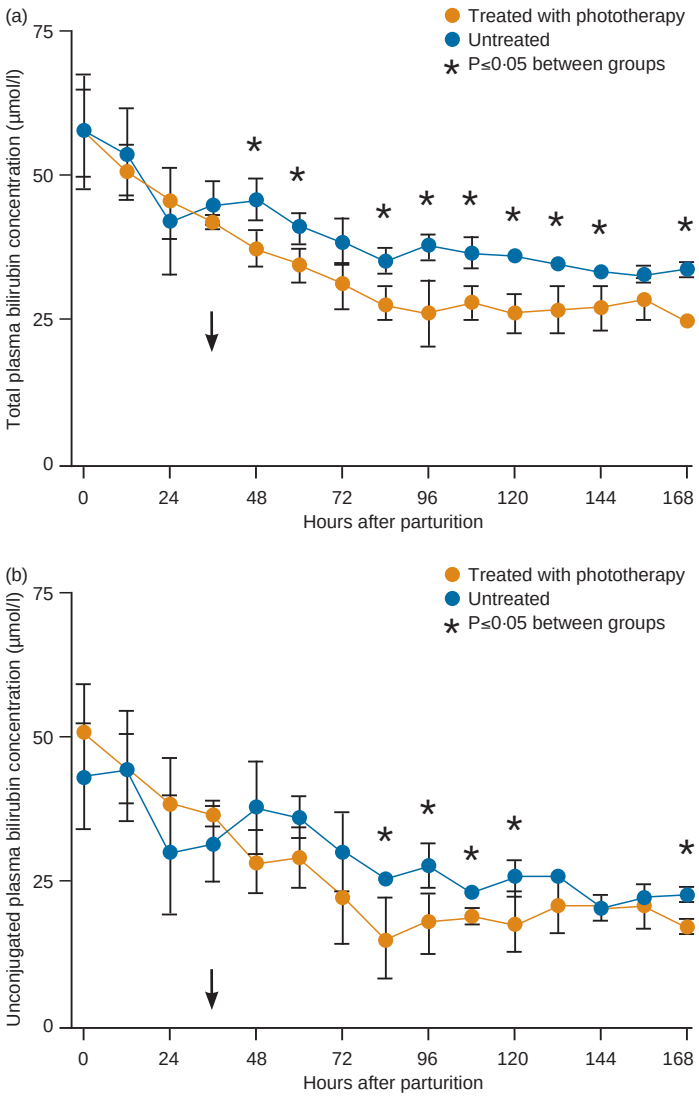


**FIG 2: (a) Total and (b) unconjugated plasma bilirubin concentration for the 168 hours after birth in foals that received phototherapy and untreated foals. Each point represents mean ±sd. Arrows indicate the beginning of phototherapy treatment**

and unconjugated (UB) plasma bilirubin concentrations in a blood chemistry analyser (Microlab 100; Merck), based on the Jendrassik-Grof method (Jendrassik and Grof 1938). Differences in TB and UB between the two groups were determined by the Mann-Whitney test, and were considered significant when P≤0·05.

Total plasma bilirubin concentrations (Fig 2a) showed a declining pattern in both groups. There were no differences between the groups from birth (untreated: 58·14±9·57 µmol/l, phototherapy: 57·71±7·57 µmol/l) until 36 hours after birth (untreated: 45·32±3·56 µmol/l, phototherapy: 42·32±1·64 µmol/l). From 48 hours after birth, the TB pattern in the foals treated with phototherapy showed a more accentuated decrease than the untreated control group, with significantly (P<0·05) lower TB concentrations at almost all the sample points, except at 72 and 156 hours of life. Final values (at 168 hours) for TB were 25·05±1·34 µmol/l and 33·77±1·64 µmol/l for the phototherapy and the control groups, respectively.

UB concentrations (Fig 2b) also decreased from birth (untreated: 43·82±9·58 µmol/l, phototherapy: 51·68 ±7·75 µmol/l) to the end of the study (untreated: 23·21±1·54 µmol/l, phototherapy: 17·67±2·33 µmol/l), showing patterns similar to TB for the corresponding groups. The UB concentrations were significantly lower at 84, 96, 108, 120 and 168 hours after parturition in the phototherapy group (P≤0·05).

There was no difference in haematocrit during the study between the untreated control (35·85±2·16 per cent) and the phototherapy (35·31±2·96 per cent) groups, and the values were in agreement with those in the literature for the same period of the foals' life (Wilson 1988, Parraguez and others 2002).

There are no data in the literature on foal bilirubin covering the entire neonatal period studied in this work. However, the results for TB are in the range described previously for 24 and 168 hours after birth (Harvey 1990). The rapid and constant decline of TB and UB in the group treated with phototherapy, which reached significantly lower concentrations than that of the control foals at the end of the study, confirms the effect of blue fluorescent light on bilirubin metabolism previously described in human beings (McDonagh 1985, Ennever 2004). Furthermore, the similar behaviours of TB and UB suggest that phototherapy has a major effect on unconjugated bilirubin, the most toxic form of bilirubin for nervous tissue (Cashore 2004).

To the authors' knowledge, this is the first study on the effect of phototherapy on plasma bilirubin concentration in foals. Although this therapy should be tested on hyperbilirubinaemic/jaundiced animals, the present results indicate that phototherapy is a promising therapeutic tool for preventing the effects of hyperbilirubinaemia in foals.

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