Abstract

As a consequence of the fragility of various neural structures, preterm infants born at a low gestation and/or birthweight are at an increased risk of developing motor abnormalities. The lack of a reliable means of assessing motor integrity prevents early therapeutic intervention. In this paper, we propose a new method of assessing neonatal motor performance, namely the recording and subsequent analysis of intraoral sucking pressures generated when feeding nutritively. By measuring the infant’s control of sucking in terms of a new development of tau theory, normal patterns of intraoral motor control were established for term infants. Using this same measure, the present study revealed irregularities in sucking control of preterm infants. When these findings were compared to a physiotherapist’s assessment six months later, the preterm infants who sucked irregularly were found to be delayed in their motor development. Perhaps a goal-directed behaviour such as sucking control that can be measured objectively at a very young age, could be included as part of the neurological assessment of the preterm infant. More accurate classification of a preterm infant’s movement abnormalities would allow for early therapeutic interventions to be realised when the infant is still acquiring the most basic of motor functions.

Key words

Preterm infants · Motor control · Motor abnormalities · Sucking · Tau theory · Force control

Introduction

Although advances in biomedical technology over the last two decades have brought about a decline in the mortality rates of preterm infants, morbidity rates have continued to rise (Doyle et al. 1997). Surviving infants born at a low birthweight and/or gestational age are more at risk for specific illnesses and subsequent long-term complications associated with their preterm condition. Brain injury in particular poses a significant problem, with its multifaceted aetiology. For instance, the preterm infant’s cerebral cortex lacks the arterial maturation seen in the new-born term infant, with fragile capillaries and poor autoregulation of the vascular system increasing the risk of cerebral haemorrhaging, particularly in the periventricular region. The situation can be further exacerbated by the subsequent reabsorption of the haemorrhaged blood, which appears as cysts on the developing cortex. In addition to this, retarded development of arterial branches and cells, such as the oligodendroglia, further increases the likelihood of neurological insult (Gilles et al. 1983; Rorke 1992). Statistics suggest that, of the surviving preterm infants born at less than 1500 g, 5–15% will develop major spastic motor deficits or cerebral palsy, with a further 25–50% of infants showing milder developmental disabilities (Volpe 1994). This risk of neurological impairment also increases as a function of birthweight and/or gestational age (Vandenbarg 1990).

The improvement in scanning techniques has meant that neurological abnormalities, such as lesions, haemorrhages and cysts, can be detected in the preterm infant. Techniques such as magnetic resonance imaging (MRI) give good anatomical definition and, therefore, allow the clinician to see the shape and the form of various cortical structures and, hence, assess the extent of the infant’s cortical abnormalities. The use of 3D MRI in conjunction with image processing algorithms provides further insight into the cerebral and cortical development of the preterm infant in vivo (Huppi et al. 1998). Studies have shown a relationship between cortical abnormalities as seen on MRI scans with the neurological outcome of preterm in-
fants (e.g. Cioni et al. 1992; Sie et al. 1997). However, certain other studies have questioned the validity of MRI scans as a means of predicting future neurological outcome. Skranes et al. (1998), for instance, found no relationship between abnormal MRI scans and fine motor, intellectual or perceptual functions in very low birthweight infants. Similarly, another study investigating the relationship between periventricular leukomalacia (PVL), as detected by MRI scans, and the behavioural problems in school-age preterm infants concluded that the presence of PVL is not necessarily associated with abnormal neurological findings (Olsen et al. 1997).

Prognostic techniques, such as background electroencephalograms (EEG) (Biagoni et al. 1996), have provided an alternative means of detecting neurological abnormalities in preterm infants. By monitoring the maturation of a certain type of rhythmic theta activity termed “temporal sawtooth”, researchers were able to identify infants who had neurological abnormalities (Biagoni et al. 1994). However, not all abnormal background EEG activity is indicative of neurological abnormalities. Care must be taken when identifying the poignant characteristics of the EEG trace, as drugs administered to the preterm infants during their care may be the source of the abnormalities in the traces (Holmes and Lombroso 1993).

Although the above-mentioned techniques each have a role to play in detecting neurological abnormalities in the brain, they do not give any indication as to what the consequences are for the preterm infant at the behavioural level. In an attempt to overcome this shortcoming, numerous studies have looked at the production of general spontaneous movements in preterm infants (Cioni et al. 1997; Prechtl et al. 1997). Research has shown that it is the quality rather than the quantity of the general spontaneous movements that correlates most strongly with the infants neurological outcome (Bos et al. 1997a, 1997b). Although these assessments of movement quality provide a key to the functioning of the central nervous system, they do, however, depend on the subjective evaluations of trained observers and, therefore, lack global reliability and application. In addition to this, drugs like dexamethasone can have debilitating effects on the production of spontaneous movements (Bos et al. 1998). Another problem is that, given the lack of goal direction in spontaneous movements, it is difficult to extrapolate the infant’s intention. Perhaps a more objective analysis that looks at the kinematic aspects of an early-developing motor skill in detail may, however, provide more enlightenment about the infant’s motor capabilities and deficits.

In the field of motor control, the literature points to the finding that neurological insult is frequently characterised by irregular temporal control of limb movement (Isenberg and Conrad 1994). This is clearly illustrated in the cases of Parkinson’s Disease, cerebral palsy and patients suffering cerebellar lesions, where movements have irregular velocity profiles. Another characteristic of abnormal motor behaviour, as seen with patients suffering from Parkinson’s disease, cerebellar, premotor and supplementary-motor-area lesions, is an inability to accurately reproduce different temporal aspects of movements (see Ivry 1997 for a review). Perhaps, therefore, neurological abnormalities that result in motor problems in a preterm infant might be revealed by measuring the temporal control of a given motor skill.

In this paper, a diagnostic technique based on a measurement of the temporal control of intraoral sucking pressures is proposed. In a previous study with healthy term infants (Craig and Lee 1999), a measure of the temporal control of sucking pressures was developed and tested. By using this measure (explained below in the Methods section), we found that the temporal control of sucking pressures in the infants was of similar form to the temporal control of reaching movements by normal adults (Lee et al. 1999). Sucking, a precocious motor skill that is functionally incorporated into the preterm movement repertoire at around 32 weeks gestational age (Hack et al. 1985; Goldson 1987), is a complex behaviour that can provide valuable insights into the integrity of the central nervous system. Successful sucking is dependent on intact brain-stem pathways and the transmission of impulses through the cranial nerves to healthy musculature in the mouth, tongue and pharynx. The coordination of the movement of these various oro-motor structures control the changing intraoral pressures that occur during a suck cycle. Injury to or dysfunction in any of these regulatory systems could manifest itself in abnormal sucking (Coulter and Danner 1987) or, more specifically, in the regulation of intraoral sucking pressures that ultimately control milk flow (Mathew 1991). It is therefore hypothesised that irregularities in the control of sucking pressures, as detected by the proposed temporal measure, may provide a sensitive means of assessing motor abnormalities in preterm infants.

The aim of this paper is, therefore, twofold. Firstly, we wanted to see if there were any differences in the temporal control of sucking pressures between the preterm infants and the term infants, and, if so, do these differences diminish as the preterm infants mature. Secondly, if these significant differences persisted, we wanted to see if they manifested themselves in the form of motor delays several months later.

Method and materials

Subjects

Six bottle-feeding preterm infants, born at less than 29 weeks gestational age and weighing less than 1450 g, were tested. All were classified as having bronchopulmonary dysplasia (BPD), a typical preterm respiratory illness, and had just commenced bottle feeding when the first recording was taken. None of the infants were classified as neurologically at high-risk; hence, no MRI scans were carried out. Further details relating to the subjects are given in Table 1. Ethical approval was granted and parental consent was given before subjects were included in the study.

Apparatus

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