Commentary

For the neurosurgeon, pneumocephalus is not an uncommonly seen entity. But for the neonatologist, it remains a rare occurrence. The data regarding neonatal meningitis leading to pneumocephalus is limited to few case reports in literature.[1-8] All of them have been associated with bacterial growth- *Clostridium perferinges*,[1-3] *Citrobacter koseri*,[4,5] *Enterobacter cloacae*,[6,7] and *Proteus mirabilis*.[8] The characteristic feature of these organisms is gas production due to putrification of intracellular protein and decomposition of glucose. No organism could be cultured either from the blood or cerebrospinal fluid (CSF) in the current report in this issue of the journal.[9] As postulated by the authors, the reason could be exposure to antibiotics prior to sampling and less than adequate laboratory techniques.

The risk factors for meningitis specifically with these organisms, apart from the known factors for neonatal sepsis, are not clear. It has been postulated that areas of reduced oxygen tension are ideal for growth of anaerobic organisms like *Clostridium perferinges.* These organisms can gain access to central nervous system either via hematogenous route (after colonization over the body surface) or by direct extension into the brain through an anatomical defect. Interestingly, none of the case report mentions loss of anatomical barrier. Unclean cutting and tying of umbilical cord and some applications could promote anaerobic bacterial growth which can invade and cause systemic sepsis. Unfortunately, the authors of the current report could not demonstrate a bacterial growth from any site.

The diagnosis of pneumocephalus is usually based upon ultrasound and computed tomography (CT) findings. Ishiwata *et al*.,[10] have given two important signs of identifying tension pneumocephalus in adults: 'Mt Fuji' sign caused by subdural air which separates and compresses the frontal lobes, creating a widened interhemispheric space between the tips of the frontal lobes and 'air bubble' sign which is due to the presence of multiple small air bubbles scattered through several cisterns. Newborns, owing to their soft skull and open anterior fontanelle, may not show Mt Fuji sign. In the current report, CT scan showed the characteristic air bubble sign. In the newborn, a very useful bedside diagnostic technique can be the use of a cold light transilluminator in a relatively darkened room. Transilluminators are available in the neonatal intensive care units (NICUs) for the rapid bedside diagnosis of pneumothorax in ventilated infants.

Treatment of small pneumocephalus is largely conservative with slight head end elevation, avoidance of high positive end expiratory pressure, and pain control.[11] Various other modalities have been tried in postoperative pneumocephalus which include giving normobaric oxygen to resolve the pneumocephalus.[12] Feasibility and applicability of this modality in neonatal population have not been tested in any of the case reports. Theoretically, the gas produced by the microorganisms will be different from the entrapped air in postoperative patients. If the pneumocephalus is large enough to increase intracranial tension, it would have to be drained with a large bore needle as happened in the current case report.

Prognosis of the pneumocephalus secondary to meningitis is very poor. None of the infants reported in the case studies survived. The reason for this poor prognosis could be a delay in diagnosing this very rare condition and the fulminant nature of the infection. Bedside transilluminator and ultrasound can provide a rapid diagnosis and lead to earlier intervention. The infants should be promptly treated with broad spectrum antibiotics which also cover anaerobes. Piperacillin-tazobactam combined with an anti-staphylococcal antibiotic should be good empirical antibiotic choice in these cases.

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