Prophylactic indomethacin for preterm infants: a systematic review and meta-analysis

P W Fowlie, P G Davis

Background: Rates of long term morbidity remain unacceptably high in infants surviving after preterm birth. Prophylactic indomethacin has been shown to effectively reduce the rate of intraventricular haemorrhage in this group but there is the potential for unwanted side effects because of reduced organ perfusion.

Objective: To examine the effect of prophylactic indomethacin on mortality and short and long term morbidity of preterm infants.

Data sources: Medline (1966–2002), the Cochrane Controlled Trials Register and abstracts of the Society for Pediatric Research and the European Society for Pediatric Research were searched independently by both authors.

Review methods: Trials were included if they used a randomised design, enrolled preterm infants given intravenous indomethacin within 24 hours of birth, and reported any of the prespecified outcome measures. Each author extracted data and assessed trial quality independently, according to the methods of the Cochrane Collaboration. Data were combined in a meta-analysis where appropriate.

Results: Nineteen trials fulfilling the inclusion criteria were identified, of which four reported long term outcomes. Short term benefits of indomethacin were identified, including a reduction in the rate of severe intraventricular haemorrhage [relative risk (RR) 0.66 (95% confidence interval (CI) 0.53 to 0.82)] and the need for surgical ligation of a patent ductus arteriosus [RR 0.51 (95% CI 0.37 to 0.71)]. No evidence of short term gastrointestinal or renal adverse effects was detected. There was no significant difference between indomethacin and control groups with respect to the important long term outcome of death or severe neurosensory impairment (RR 1.02 (95% CI 0.90 to 1.15)).

Conclusions: Prophylactic indomethacin has a number of short term benefits for the preterm infant but there is no evidence to suggest that it results in an improvement in the rate of survival free of disability.

Inclusion criteria
Both authors assessed all published articles and abstracts identified as potentially relevant by the literature search for inclusion in the review. In order to be included, trials had to meet all four of the following criteria:

- Study design: randomised controlled trials
- Participants: preterm infants
- Intervention: intravenous indomethacin given within 24 hours of birth
- Outcome measures: included any of the following—death, IVH, PDA, or long term neurodevelopmental outcome

Quality assessment and data abstraction
Both authors assessed each article according to the following criteria: bedding of randomisation, blinding of intervention, completeness of follow up, and blinding of outcome

Abbreviations: IVH, intraventricular haemorrhage; PDA, patent ductus arteriosus; RR, relative risk; CI, confidence interval
assessment. Both authors extracted the data from each trial independently, then compared results and resolved differences.

Data analysis
Data measuring similar outcomes were combined in a meta-analysis where appropriate. For categorical outcomes, treatment effect was analysed using relative risk (RR), risk difference, and number needed to treat with their 95% confidence intervals (CI). A fixed effects model was used. Evaluation of heterogeneity of results was performed for all outcomes, and $p < 0.05$ on $\chi^2$ test was considered to represent significant heterogeneity.

RESULTS
Quality assessment
Nineteen randomised trials comprising 2872 infants fulfilled the inclusion criteria. Four of these reported long term outcomes (1862 infants). The exact method of randomisation was specified in 12 of the studies.4–14 Methods included telephone randomisation, sealed envelopes, and coded drug vials. In the remaining seven trials it was not possible to determine how well the process of randomisation was blinded.15–21 In three studies it was not possible to determine whether the caregivers and those assessing the outcomes of interest were blinded to the intervention group.17 19 20 In the remainder there was adequate description of methods used to ensure blinding including description of the placebo.

Follow up rates for short term outcomes were adequate—that is, >90%—for all included studies. Long term follow up rates were less complete, ranging from 75% to 100%.

Trial characteristics
Table 1 shows clinical details of included studies. Some clinical practices changed over time—for example, surfactant was given either as prophylaxis or rescue therapy in seven trials.4 10–14 16

Quantitative data synthesis
Table 2 shows the pooled results of the trials. There was no difference in mortality to latest follow up between the treatment and placebo groups (RR 0.96 (95% CI 0.81 to 1.12)). The reduction in cranial ultrasound abnormalities (all IVH (RR 0.88 (95% CI 0.80 to 0.96)) and severe (grades 3 and 4) IVH (RR 0.66 (95% CI 0.53 to 0.82)) seen in the treatment group did not translate into improved long term outcomes. Rates of mortality and severe neurosensory impairment (blindness, deafness, cerebral palsy, or developmental quotient more than two standard deviations below the mean) were high in this group of infants and were not decreased by prophylactic indomethacin (RR 1.02 (95% CI 0.90 to 1.15)).

There were some short term advantages observed in infants given indomethacin. The rate of PDA (RR 0.44 (95% CI 0.38 to 0.50)) and particularly the rate of surgical ligation for this condition (RR 0.51 (95% CI 0.37 to 0.71)) were reduced in the treatment group. Twenty infants would need to be treated with prophylactic indomethacin to prevent one surgical ligation. There were no differences in other short term outcomes including necrotising enterocolitis and bronchopulmonary dysplasia. Although oliguria was more often observed in infants receiving indomethacin, there were no differences in proportions of babies developing high serum creatinine levels.

Heterogeneity of results was found only for the outcome “all IVH” ($p = 0.011$). The remaining pooled outcomes had $p$ values > 0.2 for heterogeneity, indicating that variability between studies may be explained by chance alone.

DISCUSSION
There is now a substantial body of literature available to evaluate the role of prophylactic indomethacin in preterm infants. The quality of trials included in this systematic review is good but there is variation in enrolment criteria, indomethacin dosage regimens, and some of the outcome definitions.

This review confirms the usefulness of prophylactic indomethacin in the prevention of symptomatic PDA. Some clinicians would find the reduction in the need for surgical ligation of the ductus, combined with the lack of evidence for short or long term harm, justification for providing this treatment. Other factors influencing such a decision would be the background rate of ligations and the availability of cardiology and cardiac surgery services.

In the past, the presence of a PDA was thought to increase the risk of developing both pulmonary haemorrhage and bronchopulmonary dysplasia. Reduction in the rate of PDA

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**Table 1** Clinical details of included studies

<table>
<thead>
<tr>
<th>Study (year)</th>
<th>n</th>
<th>Participants</th>
<th>Dose*</th>
<th>Long term follow up</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bada (1989)</td>
<td>141</td>
<td>BW &lt;1500 g</td>
<td>3 doses starting at 6 hours</td>
<td>No</td>
</tr>
<tr>
<td>Bandara (1988)</td>
<td>199</td>
<td>BW &lt;1300 g</td>
<td>3 doses starting at 12 hours</td>
<td>Between 6 and 24 months: Bayley MDI and PDI</td>
</tr>
<tr>
<td>Couzer (1996)</td>
<td>93</td>
<td>BW 600–1250 g</td>
<td>6 doses starting at 24 hours</td>
<td>No</td>
</tr>
<tr>
<td>Domenico (1994)</td>
<td>100</td>
<td>BW &lt;1250 g</td>
<td>3 doses starting at 12 hours</td>
<td>No</td>
</tr>
<tr>
<td>Gutierrez (1987)</td>
<td>59</td>
<td>GA &lt;34 weeks and BW &lt;1751 g</td>
<td>3 doses starting at 24 hours</td>
<td>No</td>
</tr>
<tr>
<td>Hanigan (1988)</td>
<td>111</td>
<td>BW &lt;1500 g</td>
<td>3 doses starting at 12 hours</td>
<td>No</td>
</tr>
<tr>
<td>Krueger (1987)</td>
<td>32</td>
<td>BW 750–1300 g</td>
<td>Single dose at 24 hours</td>
<td>No</td>
</tr>
<tr>
<td>Mahony (1985)</td>
<td>110</td>
<td>BW 700–1300 g</td>
<td>3 doses starting at 12–18 hours</td>
<td>No</td>
</tr>
<tr>
<td>Ment (1983)</td>
<td>48</td>
<td>BW 600–1250 g</td>
<td>5 doses starting at 6 hours</td>
<td>No</td>
</tr>
<tr>
<td>Ment (1998)</td>
<td>36</td>
<td>BW 600–1250 g</td>
<td>3 doses starting at 6–12 hours</td>
<td>No</td>
</tr>
<tr>
<td>Ment (1994a)</td>
<td>61</td>
<td>BW 600–1250 g</td>
<td>3 doses starting at 6–12 hours</td>
<td>No</td>
</tr>
<tr>
<td>Ment (1994b)</td>
<td>431</td>
<td>BW 600–1250 g</td>
<td>3 doses starting at 6–12 hours</td>
<td>At 36 and 54 months: Stanford Binet Intelligence Scale Peabody Picture Vocabulary Test (R), CP, blindness, deafness</td>
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<tr>
<td>Morales-Suarez (1994)</td>
<td>80</td>
<td>GA 28–36 weeks</td>
<td>3 doses starting at 12 hours</td>
<td>No</td>
</tr>
<tr>
<td>Puckett (1983)</td>
<td>32</td>
<td>BW &lt;1400 g</td>
<td>3 doses starting at 24 hours</td>
<td>No</td>
</tr>
<tr>
<td>Rennie (1986)</td>
<td>50</td>
<td>BW &lt;1750 g</td>
<td>3 doses starting at 24 hours</td>
<td>No</td>
</tr>
<tr>
<td>Supapannachart (1999)</td>
<td>30</td>
<td>BW &lt;1250 g</td>
<td>3 doses starting at 24 hours</td>
<td>No</td>
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<tr>
<td>Schmidt (2001)</td>
<td>1202</td>
<td>BW 500–999 g</td>
<td>3 doses starting at 6 hours</td>
<td>At 18 months: Bayley MDI, blindness, deafness, CP, cerebral palsy</td>
</tr>
<tr>
<td>Vincer (1987)</td>
<td>30</td>
<td>BW &lt;1500 g</td>
<td>3 doses starting at 12 hours</td>
<td>At 24 months: CP</td>
</tr>
<tr>
<td>Yaseen (1997)</td>
<td>27</td>
<td>BW &lt;1750 g</td>
<td>3 doses starting at 12 hours</td>
<td>No</td>
</tr>
</tbody>
</table>

*Dosages were either 0.1 or 0.2 mg/kg and dosing interval 12 or 24 hours.
BW, Birth weight; GA, gestational age; MDI, mental developmental index; PDI, physical developmental index; CP, cerebral palsy.
without a significant change in rates of bronchopulmonary dysplasia or pulmonary haemorrhage challenges traditional assumptions about the pathophysiology of these conditions. This review confirms the significant reduction in rates of severe intraventricular haemorrhage in infants given indomethacin. This result is not accompanied by any of the adverse outcomes that were possible given the vasoconstrictive nature of the drug—that is, important renal side effects, gastrointestinal perforation, and necrotising enterocolitis. However, the improvement in rates of IVH did not translate to improvement in rates of neurosensory impairment. One clear message of this systematic review is that traditional surrogate outcomes used in evaluating interventions in preterm infants may not be sufficient to guide changes in treatment. Put another way, when new interventions are being given prophylactically (and therefore to some infants who are not expected to benefit from them), long term outcomes should be assessed.

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REFERENCES