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ORIGINAL ARTICLE

Technology use, cesarean section rates, and perinatal mortality at Danish maternity wards

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Fifty-eight Danish maternity units, managing 99% of Danish deliveries, participated in a cross sectional study to assess the relationship between use of birth-related technologies, cesarean section rates and perinatal mortality for births after 35 completed weeks of gestation. A regional technology index (0–10) was calculated for each maternity unit according to its use of ante and intra partum fetal heart rate monitoring (FHM), hormone analysis (human placental lactogen (HPL) and/or estriol (Ø3)), fetal blood samples (scalp-pH), intrauterine catheter and umbilical cord-pH. Maternity units using FHM had a 15% higher cesarean section rate (not planned) than units not using FHM ($p < 0.05$). The referral of potentially complicated deliveries to central units, which at the same time relatively often use FHM, is probably responsible for this association. Trying to encounter this selection bias a technology index was calculated for eight regions in Denmark, weighting the index of each unit in a region according to its number of deliveries. There was no association between the technology index in these eight regions in Denmark and their cesarean section rates. Use of FHM, technology index, and unplanned cesarean section rates in the eight regions were all without significant association to the perinatal mortality in the same regions. For births after the 35th completed week of gestation, this study could not confirm a relationship between *different degrees of* use of birth-related technologies and perinatal mortality.

Key words: perinatal mortality; fetal heart rate monitoring; cesarean section; technology assessment; birth technologies

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The use of birth-related technologies and the frequency of cesarean sections has increased during the last two decades. Parallel to this development the perinatal mortality for all gestational ages has decreased worldwide (1–4). Three questions are still of major concern:

1. Is the increasing use of technologies responsible for the reduced perinatal mortality ?
2. Are the increasing cesarean section rates a consequence of the increasing use of technologies?
3. Is the reduced perinatal mortality in part a result of the increased cesarean section rates?

Existing empirical data do not permit definitive statements on these questions. Technology assessment of birth-related technologies is complicated by the fact that we have only relatively crude measures of the newborn's health (mortality, clinical neurological investigation, cerebral CT or ultrasound examinations) or measures which are not strictly objective (Apgar score, routine clinical examination) or measures which have an uncertain prognostic value (cord-pH).

Furthermore, women with complications in pregnancy are referred to central maternity units which therefore *a priori* are expected to have a

Abbreviations:
FHM: fetal heart rate monitoring; HPL: human placental lactogen.

Table I. A technology index (0–10) was calculated for each maternity unit according to the use of different perinatal technologies

Ante-partum FHM: used on indication: 1, not used: 0.
Intra partum FHM: routine: 2, on indication: 1, not used: 0.
Scalp-pH: used frequently: 2, rarely: 1, never: 0.
Cord-pH: routine: 1, not routine: 0.
Intrauterine catheter: routine: 2, on indication: 1, never used: 0.
Hormone analysis (HPL and/or estriol): routine: 2, on indication: 1, never: 0.

FHM = fetal heart rate monitoring.

Table II. Fifty-eight Danish maternity units, managing 99% of Danish deliveries were distributed to eight regions according to their county of residence. The regional number of births after 35 completed weeks of gestation in 1988–1990 is indicated

Region 1: Copenhagen City and county and Frederiksberg City	39,099
Region 2: Frederiksborg county	11,709
Region 3: Roskilde, Vestsjælland, Storstrøms and Bornholm county	26,293
Region 4: Fyns county	15,642
Region 5: Sønderjylland, Ribe and Vejle county	29,142
Region 6: Århus county	22,006
Region 7: Ringkøbing and Viborg county	18,587
Region 8: Nordjylland county	17,094
Total	179,572

relatively high rate of cesarean sections and other obstetrical complications. Any study seeking to assess the benefits of birth-related technologies, therefore, must account for these circumstances. Among other things this can be done by assessing the use of technology and the mortality, not at department levels, but in different regions, each including referral units.

The aim of this study was for births after 35 completed weeks of gestation to correlate mutually the use of birth-related technologies, the perinatal mortality and the cesarean section rates in Denmark. The analyses included:

1. a correlation analysis between the use of birth-related technologies in general and cesarean section rates as well as the perinatal mortality,
2. a correlation analysis between use of specifically intrapartum FHM and cesarean section rates/the perinatal mortality, and
3. a correlation analysis between cesarean section rates and perinatal mortality at Danish maternity units.

Material and methods

The use of birth-related technologies was investigated by an enquiry returned from the heads of all 58 maternity units in Denmark in May 1989 (5). A 'technology index' was calculated for each unit according to the use of ante and intra partum FHM, intrauterine catheter, fetal blood sample (scalp-pH), cord-pH and hormone analysis (human placental lactogen and/or estriol) (Table I), resulting in index-values between 0 and 10. Although cord-pH does not influence a specific delivery, a routine analysis may very well be of significance for the alertness among the obstetricians at that unit. The inclusion of hormone analysis was based on the fact that not less than 93% of Danish maternity units (54/58) use that analysis routinely or on indication (5). A technology index for each county was then calculated, by weighting the index of each unit to its number of deliveries. These counties finally based the construction of eight regional technology indices (Table II and Table III).

The National Board of Health in Denmark provided data on cesarean section rates (1987) and perinatal mortality (1988–1990) for each unit. From these figures weighted mean cesarean section rates and mortality statistics for the eight regions were calculated.

Pre-term infants constitute a significant part of perinatal deaths. However, the aim of this study was to investigate the significance of technology use for term or near term deliveries. Therefore only

Table III. Technology index, cesarean section rates, and perinatal mortality in eight regions in Denmark for births after 35 completed weeks of gestation

	Technology index (Score 0–10)	Cesarean section		Perinatal mortality (per 1000)			
		Unplanned %	Total %	Still born	Dead first week	Total	*N*
Region 1	6.8	8.8	12.8	2.6	1.7	4.3	(170)
Region 2	4.3	10.6	15.9	3.0	2.6	5.6	(65)
Region 3	3.6	8.4	13.1	3.7	1.6	5.3	(140)
Region 4	4.0	9.0	13.9	2.6	1.9	4.5	(71)
Region 5	2.8	7.4	11.5	3.2	1.5	4.7	(137)
Region 6	5.5	5.6	8.4	3.3	2.0	5.3	(116)
Region 7	3.3	6.6	11.1	2.8	1.5	4.3	(79)
Region 8	4.2	6.1	15.6	4.0	1.3	5.4	(92)
Average	4.5	7.7	11.9	3.1	1.7	4.8	(870)

births and cesarean sections after 35 completed weeks of gestation were included. In the analysis of cesarean sections, separate analyses were made for planned and unplanned sections.

Differences were tested by the χ^2-test.

Results

The calculated technology indices are shown in Table III. Corresponding cesarean section rates and perinatal mortality rates are illustrated in the same Table.

Firstly the correlation between intra partum FHM and unplanned cesarean sections was analyzed, including all 58 maternity units. Departments using routine intra partum FHM and FHM on indication had on average 7.8% and 7.6% unplanned cesarean sections (p NS). Units which never used FHM had on average 6.5% unplanned cesarean sections ($p < 0.05$).

Secondly, the influence of regional technology indices on the cesarean section rates was analyzed (Fig. 1). No significant trend was found.

The perinatal mortality was not influenced by the cesarean section rates in the eight regions (Fig. 2). Thus, the highest perinatal mortality rates occurred in regions with the highest and next lowest unplanned cesarean section rates.

The significance of intra partum FHM for the perinatal mortality is illustrated in Fig. 3. The per cent of deliveries in each region taking place in maternity units using FHM routinely were compared with the perinatal death rate in the same eight regions. No significant trend was found.

Finally, the technology indices in the eight regions were correlated to the perinatal mortality rates, the ante partum deaths and the neonatal deaths in the same regions (Fig. 4). No significant trend was found. Changes in the technology index by excluding one or more technologies (e.g. hormone analyses and/or cord-pH) did not change this lack of association.

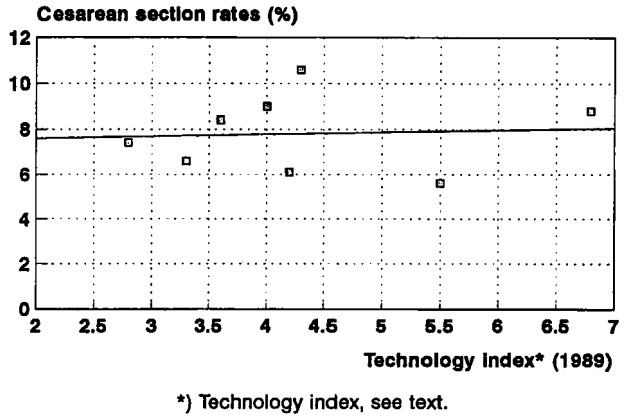


Fig. 1. Use of birth-related technologies and cesarean section rates in eight regions of Denmark. Births after 35 completed weeks of gestation.

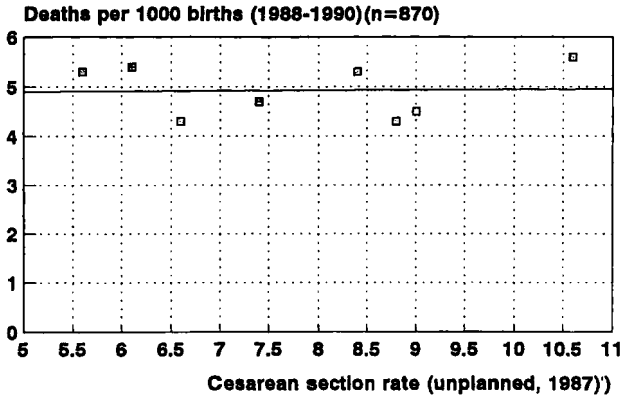


Fig. 2. Cesarean section rates and perinatal mortality in eight regions of Denmark. Births after 35 completed weeks of gestation.

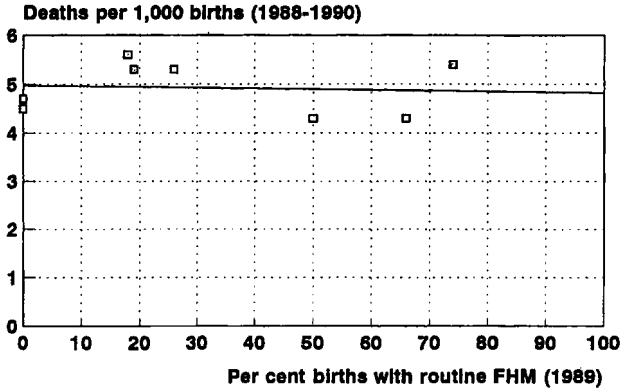


Fig. 3. Intra partum fetal heart rate monitoring (FHM) and perinatal mortality in eight regions of Denmark. Births after 35 completed weeks of gestation.

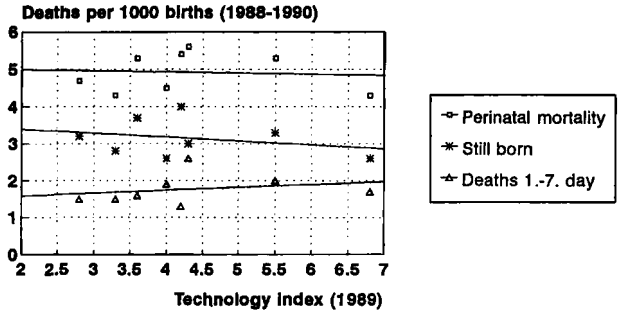
Discussion

FHM and cesarean section rates

A number of previous studies have demonstrated an increased cesarean section rate after the introduction of FHM (2–4, 6–8). In a Danish maternity unit, Qvist et al. demonstrated an increase in the cesarean section rate from 6.4% before to 9.1% after the introduction of FHM (9). Similar results were found by Greenland et al. for low risk deliveries (10).

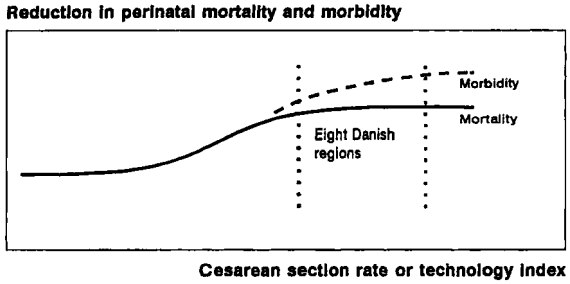
The association between use of FHM and cesarean section rates at department level may be influenced by the referral of at risk pregnancies to central units, which at the same time relatively often use FHM.

The unplanned cesarean section rates at the five departments frequently using scalp-pH was on av-



Total number of births >35 weeks 1988-1990: 179,572
Still born: n=563, deaths 1.-7. day: n= 307, perinatal deaths: n=870

Fig. 4. Technology use and perinatal deaths. Eight regions of Denmark. Births after 35 completed weeks of gestation.



As long as regions with a relatively high technology use or Cesarean section rate are compared, differences in mortality will not appear, despite the potential significance for the morbidity

Fig. 5. A suggested relationship between use of birth-related technologies/cesarean section rates and reduction in perinatal mortality or morbidity.

erage 7.3% against a country average of 7.7% (NS). All five departments, however, were major central maternity units managing more than 20% of Danish deliveries. These departments were *a priori* expected to have a relatively high per cent of cesarean sections, according to the referral of potentially complicated deliveries. These circumstances taken into account suggest that scalp-pH measurements may indeed reduce the cesarean section rates.

At regional level no association was found between use of any of the included birth-related technologies and the cesarean section rates.

Cesarean section rates and perinatal mortality

Stillbirths and deaths within first week constitute respectively about 2/3rds and 1/3rd of the perinatal mortality. Preterm births are responsible for about 2/3rds of these deaths. Trying to reduce the bias resulting from referring pre-term deliveries to the central maternity units, we included only deliveries after 35 completed weeks of gestation.

Evaluation of the present results is difficult. The only conclusion which can be drawn immediately is that (with a certain statistical probability) there is no crude correlation between differences in cesarean section rates and perinatal mortality in the eight analyzed Danish regions. This missing correlation can be the result of two circumstances:

1) that no relationship really exists
2) that a really existing association is hidden by methodological circumstances.

Before analysing the last possibility, it ought to be mentioned that a missing correlation between differences in cesarean section rates and perinatal mortality naturally cannot be taken as a token of a non-association between use versus no use at all of cesarean sections on the one hand and perinatal mortality on the other hand. Figure 5 suggests this circumstance. At some point a further increase in use of technologies and/or in cesarean sections will not reduce the perinatal mortality any further. If all eight regions analyzed in this study are placed on the flat plateau of the curve, no differences in perinatal mortality will appear according to differences in cesarean sections, despite the fact that in all regions this intervention reduces the mortality. Secondly, a missing association between differences in cesarean section rates and perinatal mortality does not exclude a significance for the newborn's morbidity, suggested by the dotted line in Fig. 5.

Other possible explanations may, however, have influenced the missing association. First, the figures may have been too small to detect a real association (type-2 error). However, the figures were not that small, and there was no trend of a relationship. Therefore this possibility does not seem very likely.

Another theoretical possibility is that children born in regions with a high cesarean section rate have an *a priori* higher perinatal mortality than children born in regions with a low section rate, the high cesarean section rate in the former regions counterbalancing this potential selection bias. Although this possibility cannot be definitively excluded, no existing empirical data support it.

Differences in neonatal service may have influenced the figures. If this were the case, a correlation analysis between cesarean section rates and that part of perinatal deaths constituted by the stillborn (on which neonatal service hardly has any major influence) should have indicated a different picture. This was not the case.

The most likely explanation is that all eight regions analyzed do cesarean sections on the greatly endangered babies, and that differences in cesarean section rates concern indications where the babies do not have a high risk of death within the first week of life. In other words the authors believe that the technology practice in all eight regions are placed at the flat right plateau of the curve in Fig. 5. If this is

true, our data suggests that for deliveries after 35 completed weeks of gestation any further increase in the cesarean section rate from about 8–10 per cent will not further reduce the perinatal mortality. Although higher cesarean section rates may be of significance for the morbidity, this finding is food for thought in the light of the still increasing cesarean section rates worldwide (11, 12).

FHM and perinatal mortality

Unplanned cesarean section is not the only possible intervention when the fetus is endangered. Therefore, an association between use of birth-related technologies and perinatal mortality could be present, without a correlation between cesarean sections and deaths. Such an association, however, was not apparent.

For high risk deliveries, Greenland et al. found a non significant reduction in perinatal mortality and frequency of low Apgar score of 40% by monitored deliveries versus deliveries without FHM (10).

A number of other studies could not establish a significant effect of intra partum FHM on the perinatal mortality (8, 13–15). In the 'Dublin-study', 12,964 women were randomised to FHM or intermittent auscultation (15). There was no difference in perinatal mortality or in frequency of low Apgar score between the two groups. It should be noticed, however, that the auscultated group was listened to four times each hour during the first stage, and after each contraction during the second stage of labor, a practice which is only possible in few places in Denmark with the current staffing.

The lack of difference in perinatal mortality between units with routine FHM and units using FHM on indication suggests that the indications include all or nearly all fetuses at risk for stillbirth or death within the first week of life. The advantage of perinatal mortality as effect measure is its incontestable objectivity. The disadvantage is that a reduction of sublethal damages is not registered. Therefore, routine FHM may be of significance for the morbidity of the fetuses (despite conflicting results in literature (9, 10, 16)) without any measurable influence on mortality (Fig. 5). It is also important to mention that FHM for preterm births may offer a better prediction of the fetal outcome than found for births with a longer gestational age (17).

Technology index and perinatal mortality

We have not found other studies trying to correlate an integrated technology index with perinatal mortality. The missing association in this study may be a consequence of the same conditions as mentioned for the influence of FHM. Although the included technologies and the points allocated different degrees of use was arbitrarily chosen, the exclusion of some of the technologies and/or a changed weighting of the technologies included in the index did not alter the lack of an association with the perinatal mortality.

We are left with the fact that the perinatal mortality has declined significantly during recent decades and that clinicians generally are of the opinion that birth-related technologies impart useful information which reduce the perinatal deaths and sublethal damages, but that we still have no definite documentation for this opinion (15). In high risk deliveries, however, intra partum FHM may imply a reduction in the frequency of low Apgar scores (5).

Until more conclusive data emerge, we recommend reticence with uncritical routine use of the currently prevailing birth-related technologies and at the same time an intensified research on present and emerging technologies.

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