Frequency and severity of apnoea in lower respiratory tract infection in infancy

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SUMMARY Twenty four hour recordings of heart rate and respiration were made on 60 infants with lower respiratory tract infection (LRTI) during the acute phase of the illness, on 20 infants with upper respiratory tract infection (URTI), and on 21 control infants. Infants with LRTI and URTI had more apnoeic episodes of longer than 10 seconds compared with controls. The length of apnoeic episodes was greatest in the LRTI group but their frequency decreased with age. In both the LRTI and URTI groups apnoea was associated with bradycardia but the LRTI group also suffered an appreciable number of episodes of bradycardia without apnoea.

Lower respiratory tract infection (LRTI) is a common cause of hospital admission in children aged under 1 year. Apnoea has been noted in infants with severe respiratory tract infections¹ and also, in a retrospective survey, in those less severely affected.² Apnoea in babies with LRTI may also be relevant in the sudden infant death syndrome. Upper and lower respiratory tract infection, not generally sufficiently severe to explain death, have been found at necropsy in infants found dead at home,^{3 4} and it has been suggested that minor respiratory illness may trigger sudden apnoea.^{5 6}

We studied 3 groups of children; 1 group with LRTI, 1 group with upper respiratory tract infection (URTI), and 1 control group without respiratory disease to determine the incidence of apnoea. We aimed to establish whether apnoea occurred more frequently during severe illness, whether it was associated with bradycardia, and whether bradycardia occurred alone.

Patients and methods

Electrocardiographic tracings (ECG) and respiration were recorded over 24 hours on 101 infants. The LRTI group comprised 60 infants aged (mean $\pm$ SD) 16.3 ± 10.4 weeks and birthweight (mean $\pm$ SD) 2.9 ± 0.7 kg. We did not distinguish between bronchitis, bronchiolitis, or bronchopneumonia.⁷ The URTI group comprised 20 infants aged (mean $\pm$ SD) 12.1 ± 6.2 weeks and birthweight (mean $\pm$ SD) 3.2 ± 0.5 kg. The 21 control infants studied were aged (mean $\pm$ SD) 12.1 ± 6.2 weeks and birthweight (mean $\pm$ SD) 2.9 ± 0.5 kg. In all cases a full history was obtained from parents and chest x-ray films were taken. In all the LRTI and URTI

patients nasopharyngeal secretions were collected for bacterial culture and in 60% of these infants secretions were taken for viral studies.

Impedance pneumography was used to monitor respiration. Changes in transthoracic electrical impedance produced a reliable record of respiration.^{8 9} In all infants respiration signals were obtained from 2 electrodes placed on opposite sides of the chest wall, and ECG from the same 2 electrodes and a reference electrode. The monitor system was a Healthdyne infant monitor fitted with a Medilog cassette recorder (Oxford Medical Systems). Two channels of the recording system were used for the respiration and ECG signal and a third channel for timing. The recordings on the patients with URTI and LRTI were taken when the illness was severe and the tapes were stored for analysis.

The Page mode display PMD-12 (Oxford Medical Systems) which replayed the tapes at 60 times recording speed and displayed the waveforms on a 12 inch monitor was used for analysis. The reference time signal ensured that possible variations in tape speed did not produce artefacts that could be interpreted as respiration or ECG disorders. We defined apnoea as a stopped respiration signal for 10 seconds or more. When these apnoeic episodes or episodes of bradycardia of less than 80/minute (averaged over 4 heart beats) were detected, the replay stopped automatically and the events were displayed. We verified the authenticity of every event and determined its duration by studying the waveforms shown on the monitor. This eliminated any errors caused by technical problems such as poor electrode contact. For the apnoeic episodes we measured the mean heart rate (averaged over 4

beats) immediately before and during the episodes and expressed the minimum heart rate during the episode as a percentage of the heart rate immediately before apnoea occurred. Numbers of apnoeic episodes were analysed with respect to age, duration, gestation, birthweight, and severity of illness for each group using standard statistical techniques.¹⁰ The changes in heart rate were analysed similarly.

The impedance monitoring system may detect impedance changes caused by contractions of the heart. This produces signals on the respiration trace at the cardiac frequency and has been reported to cause failure in apnoea alarm systems.¹¹ Three percent of tapes were rejected from the study because a strong cardiac frequency signal was present on the respiration channel. The study was discussed and approved by both the parents and the ethical committees of the hospitals.

Results

Eighteen (90%) of the controls had fewer than 5 apnoeic episodes ≥ 10 seconds over 24 hours while 21 (35%) LRTI patients and 9 (45%) URTI patients had more than 5 attacks of ≥ 10 seconds in 24 hours. The mean number of apnoeic episodes in each group is shown in Table 1. The patients with LRTI had longer apnoeic episodes (Table 2) and 5% of these episodes were longer than 30 seconds. All patients recovered spontaneously or after stimulation. There was a clear trend towards fewer apnoeic episodes with increasing age (Figure) and this correlation was statistically significant ($P < 0.05$) for LRTI patients, but not for control or URTI groups. Eight patients with more than 30 apnoeic attacks all had LRTI.

In the LRTI group the number of apnoeic episodes was not increased by prematurity or low birthweight.

Table 1 Frequency of apnoeic episodes of 10 seconds or more

Group	No	Mean	P*
Lower respiratory tract infection	60	9.1	<0.05
Upper respiratory tract infection	20	6.6	<0.05
Controls	21	1.9	

Analysed using Wilcoxon rank test: both groups compared with controls.

Table 2 Duration of apnoeic episodes in patients with more than 5 apnoeic episodes

Group	Total No of episodes of apnoea	Duration (secs)						
		10-15 (%)	16-20 (%)	21-25 (%)	26-30 (%)	31-35 (%)	36-40 (%)	>40 (%)
Lower respiratory tract infection 21 patients	480	71	16	5.5	2.9	2.5	1.1	1.3
Upper respiratory tract infection 9 patients	121	87	5	3.4	0.8	2.5	0.8	0.8
Controls 2 patients	20	100	—	—	—	—	—	—

Figure Apnoeic episodes as a function of age

Patients with positive virology or with pathogenic bacteria in nasopharyngeal secretions did not have more apnoeic episodes. The 23 patients with LRTI who had a $Paco_2 > 5.33$ kPa (40 mm Hg) had more apnoeic episodes, but this was not statistically significant.

The episodes of bradycardia associated with apnoea for patients with more than 5 apnoeic episodes are shown in Table 3. One patient with LRTI is excluded from the table. He had 90 apnoeic episodes, in which 20 were associated with a bradycardia greater than 50%. The LRTI and URTI patients had more episodes of bradycardia of greater than 25% than the controls. (Fourfold table test, LRTI $P < 0.005$, URTI $P < 0.05$). In the LRTI group the heart rate fell below 80/minute during 54 (9%) of the apnoeic episodes.

In some patients the heart rate fell below 80/minute but the respiratory trace did not show apnoea. No

Table 3 Heart rate variation in patients with more than 5 apnoeic episodes

	Total No of episodes of apnoea	No of apnoeic episodes with a reduction in heart rate of		
		<25%	25% to 50%	>50%
Lower respiratory tract infection 20 patients	390	198	175	17
Upper respiratory tract infection 9 patients	121	88	28	5
Controls 2 patients	20	20	0	0

patients with URTI or any of the controls had more than 3 episodes of bradycardia without apnoea, but 9 patients with LRTI had more than 3 and this difference is significant ($P<0.05$, fourfold table test). In the LRTI group the number of episodes of bradycardia without apnoea was independent of age. Nine patients with more than 3 episodes of bradycardia had birthweight (mean $\pm$ SD) 2.3 ± 0.7 kg. This is significantly lower ($P<0.05$, t test) when compared with the other 51 LRTI patients. Fifty four of the 176 occasions when patients with LRTI had a heart rate less than 80, coincided with apnoea.

Discussion

We have shown that apnoea is common during LRTI in infancy. More than 5 apnoeic episodes occurred within 24 hours in 33% of the patients admitted to hospital. The duration of some of these episodes is greater than in other reports,¹² in which patients were studied during the latter stages of illness before discharge. The reduction in the frequency of apnoea with increasing age confirms other results for infants in this age range,² and is in keeping with clinical findings that younger children have more severe illness.

Although apnoea was less frequent in the URTI group than in the LRTI group, it was more frequent in the URTI group than in the controls. It has been reported that URTI may increase the incidence of apnoea⁶ because of increased airway resistance in nasal passageways.¹³ The few apnoeic episodes detected in the control group lasted less than 15 seconds. These short apnoeic episodes are a recognised phenomenon in infants.⁸

Large reductions in heart rate were associated with some of the apnoeic episodes in the LRTI and URTI patients. These episodes of bradycardia show the severity of apnoeic episodes in the LRTI and URTI groups compared with the controls, where little heart rate reduction was found.

An appreciable number of episodes of bradycardia (heart rate less than 80/minute) that did not coincide with a detected apnoea were also recorded in the

LRTI group. Nine LRTI patients with more than 3 of these bradycardias had a low birthweight. The monitoring technique used (impedance pneumography) detected only central apnoea and was unable to identify ineffective breathing during upper airway obstruction.¹⁴ Obstructive apnoea can only be detected by measuring air flow directly. The episodes of bradycardia that did not coincide with detected apnoea in the LRTI group may be caused by undetected obstructive apnoea.

Electronic monitoring is widely used to supplement close nursing observation. Our findings of marked falls in heart rate with and without detected apnoea suggest that both respiration and heart rate should be monitored.

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