



Original Research

Predicting Time-Critical Pathology and Cardiorespiratory Deterioration in Infants Retrieved for Bilious Vomiting: An Observational Study

Jake Wright, MBChB*, Bron Hennebry, MBChB

South Australia Ambulance Service MedSTAR Kids, Adelaide Airport, South Australia, Australia



A B S T R A C T

Objective: Bilious vomiting in infants is recognized as a sign of potential surgical pathology, and these infants often require retrieval from the peripheral hospital to a surgical center for specialist investigation. We set out to show the frequency of surgical pathology, time-critical pathology, and cardiorespiratory deterioration during retrieval among infants with bilious vomiting. In addition, we aimed to show whether there is an association between the need for cardiorespiratory support at the time of referral and time-critical pathology or cardiorespiratory deterioration during the retrieval.

Methods: We completed a retrospective observational study of 104 infants younger than 44 weeks' corrected gestational age retrieved for bilious vomiting or aspirates over a 103-month period identified from the electronic retrieval record database of an Australian retrieval service.

Results: Of the infants included in the study, 21 (20.19%) had a surgical pathology, 6 (5.77%) had a time-critical pathology, and 10 (9.62%) experienced a cardiorespiratory deterioration during the retrieval. Infants receiving cardiorespiratory support at the time of referral were more likely to have a time-critical pathology (risk difference [RD], 24.45%; 95% confidence interval [CI], 3.23–60.07; risk ratio [RR], 6.93; 95% CI, 1.52–31.5) and more likely to experience a cardiorespiratory deterioration (RD, 50.95%; 95% CI, 18.17–78.19; RR, 9.24; 95% CI, 3.38–25.27).

Conclusion: Our findings can help the retrieval service plan their response to referrals for infants with bilious vomiting. Awareness of the frequency of time-critical pathology and of deterioration during retrieval and the increased risk of both among those requiring cardiorespiratory support at the time of referral could inform the timing of response and team composition.

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Bilious vomiting in infants is recognized as a potential sign of surgical pathology; however, it can also occur idiopathically and resolve spontaneously. Classically, bilious vomiting is associated with malrotation with volvulus where the bowel can twist on its mesentery, leading to ischemia and risking the viability of the bowel. Other surgical pathologies can also present with bilious vomiting, typically those where the bowel is obstructed and as such is potentially at risk of perforation.¹ Loss of bowel or perforation can lead to significant long-term morbidity and mortality. These infants require specialist investigation; however, not all are born in locations where this is available, and therefore, it is often necessary for them to be

transferred to a pediatric surgical center. The number of referrals to retrieval services for infants with bilious vomiting continues to increase with a growing population and increased awareness of the potential significance of bilious vomiting as a presenting symptom of surgical pathology.^{2–4} Alongside the rest of their workload, the retrieval service is faced with the dilemma of responding to these referrals with the appropriate resources and in an appropriate timeframe.

First, retrieval services commonly use a variety of health care professionals, and there may be variation in the scope of practice of different team members. Many services, including our own, use nurse-led, as opposed to physician- or advanced practitioner-led, retrievals for patients who require pediatric-specific expertise in assessment and care but who are established on treatment or do not require significant stabilization before transfer.² Within our service, advanced

*Address for correspondence: Jake Wright, MBChB, Leeds General Infirmary, Great George Street, Leeds LS1 3EX, United Kingdom.
E-mail address: jake.wright@nhs.net (J. Wright).

interventions, which may be required for cardiorespiratory support, including intubation or siting central venous and arterial access, would be outside the scope of practice of such teams. Very often, bilious vomiting can occur in the absence of cardiorespiratory instability and the infant may appear subjectively well. However, some may deteriorate and require interventions for cardiorespiratory support to ensure that they can be safely transferred to the surgical center. The composition of the retrieval team needs to be considered before being dispatched because assigning team members with a broader skill set may limit the service's ability to respond to other referrals or waiting for such team members, if not immediately available, may lead to a delay in transfer.

Second, there is currently no consensus as to whether the transfer of infants with bilious vomiting should be treated as time-critical or not, leading to variation in practice.³ The definition of a time-critical transfer is somewhat subjective and generally refers to the transfer of a patient for interventions not available at the referring center and where delays would present a significant risk of mortality or severe morbidity. In the context of bilious vomiting, a time-critical transfer would be required for a pathology necessitating urgent surgical intervention including volvulus, where the viability of the bowel is at risk owing to ischemia, or intestinal perforation, where the infant is at risk of overwhelming sepsis.^{5,6} Although some infants may require emergency surgical intervention, owing to the risk of ischemia or perforation, for many others, this level of urgency may be unnecessary. Designation of referrals as time critical would necessitate a faster time to departure and lead to prioritization over other patients requiring retrieval. There may also be implications when considering the mode of transfer, whether this be an urban area by road where emergency response driving may be used, which carries an increased risk of road traffic collision, or in a rural area by fixed or rotary wing requiring the allocation of limited aviation resources, which would again need to be prioritized over other referrals. Although delayed intervention in infants with a time-critical pathology could potentially have dire consequences, repeated overtriage of those without can exacerbate the burden of these referrals on an already busy retrieval service.⁷

A better understanding of the risk of time-critical pathology and cardiorespiratory deterioration among infants with bilious vomiting could help retrieval services better respond to these referrals. This study aimed to identify the risk of surgical pathology, time-critical pathology, and cardiorespiratory deterioration among infants retrieved for bilious vomiting. In addition, we attempted to show whether the need for cardiorespiratory support at the time of referral is associated with a time-critical pathology or cardiorespiratory deterioration during the retrieval.

Methods

We conducted a retrospective observational study of infants retrieved for bilious vomiting by a single retrieval service (South Australia Ambulance Service MedSTAR Kids). All infants younger than 44 weeks' corrected gestational age retrieved for bilious vomiting or aspirates from December 2015 to June 2024 were identified from the electronic retrieval record database (AirMaestro) and included in the study population. Data were collected from the referral, retrieval, and follow-up documentation recorded in the electronic retrieval database as well as the patient's electronic medical record. This study received organizational approval from the South Australia Ambulance Service (SAAS-QJ-APPROVAL-0022).

Patient characteristic data including age, weight, gender, and gestation at birth were collected, in addition to whether the infant had received interventions for cardiorespiratory support at the time of referral. Outcome data collected included the following: whether the infant had a surgical pathology, whether the infant had a time-critical pathology, and whether the infant

experienced a cardiorespiratory deterioration. An infant was deemed to have a surgical pathology if there was documentation of ongoing care requiring the pediatric surgical team, whether this was operative or not. A time-critical pathology was defined as documentation of a pathology that presented a risk of loss of bowel or where there was evidence of perforation; this is consistent with definitions used in previous studies.^{5,6} An infant experiencing a cardiorespiratory deterioration was defined by documentation of new or further interventions for cardiorespiratory support after the initial referral.

Continuous variables are summarized as medians and interquartile ranges. Categorical variables are summarized as numbers and percentages. Gestation at birth was categorized according to the World Health Organization subcategories.⁸ To describe the relationship between the need for cardiorespiratory support at the time of referral and time-critical pathology and cardiorespiratory deterioration, risk differences (RDs) and risk ratios (RRs) were calculated and given with 95% confidence intervals (CIs). Where outcome data were not available, these infants were not included in the study. Where patient characteristic data were not available, these infants were not included in the calculations of the median and interquartile range. All statistical calculations were performed using MedCalc (MedCalc Software Ltd, Ostend, Belgium).

Results

Over the 103-month period, 106 infants were identified from the electronic retrieval database; of these, 104 had records with complete data relating to our outcomes of interest and were included in the study. At the time of referral, 7 infants (6.73%) had received cardiorespiratory support, with 5 (4.81%) having received fluid boluses and 2 (1.92%) receiving respiratory support.

Patient characteristic data are presented in [Table 1](#). Gender and weight at referral were similar between infants who had received interventions for cardiorespiratory support and those who had not. Although the median age at referral was similar between the 2 groups, the range was skewed for the infants who had received interventions for cardiorespiratory support at the time of referral by 2 infants, referred at 26 and 71 days of age. A greater proportion of infants who had received interventions for cardiorespiratory support at the time of referral were born preterm than those who had not (42.86% vs. 18.56%).

In our series, 21 cases (20.19%) were found to have a surgical pathology; the range of surgical pathology is presented in [Table 2](#). There were 6 cases (5.77%) of a time-critical pathology, 3 cases (2.88%) with malrotation with volvulus, and 3 cases (2.88%) with evidence of perforation, found in 1 infant with necrotizing enterocolitis, 1 infant with an intestinal infarction, and 1 infant with a spontaneous perforation.

Across the series, 10 infants (9.62%) experienced a cardiorespiratory deterioration; all of these infants received fluid boluses, and 1 was intubated and commenced on mechanical ventilation by the retrieval team ([Table 3](#)).

Infants receiving cardiorespiratory support at the time of referral were more likely to have a time-critical pathology with an RD of 24.45% (95% CI, 3.23–60.07) and a relative RR of 6.93 (95% CI, 1.52–31.5).

Infants receiving cardiorespiratory support at the time of referral were more likely to require further interventions for cardiorespiratory support with an RD of 50.95% (95% CI, 18.17–78.19) and a relative RR of 9.24 (95% CI, 3.38–25.27).

Discussion

In our study, we found that a surgical pathology was identified in 20.19% of infants retrieved for bilious vomiting or aspirates, which is comparable with similar studies in which a surgical pathology was

Table 1
Patient Characteristics

Characteristic	Total Cohort (N = 104)	Infants Who Had Not Received Cardiorespiratory Support at the Time of Referral (n = 97)	Infants Who Had Received Cardiorespiratory Support at the Time of Referral (n = 7)
Weight at referral, kg, median (IQR)	3.2 (2.77–3.6)	3.23 (2.83–3.6)	2.51 (2.27–3.49)
Unavailable	3	2	1
Age at referral, days, median (IQR)	2 (1–3)	2 (1–3)	5 (2.25–21.25)
Unavailable	3	2	1
Gender, n (%)			
Male	52 (50)	44 (45.36)	4 (57.14)
Female	47 (45.19)	48 (49.48)	3 (42.86)
Unavailable	5 (4.81)	5 (5.15)	0
Gestation at birth, n (%)			
Term	74 (71.15)	71 (73.2)	3 (42.86)
Moderate to late preterm	18 (17.31)	18 (18.56)	2 (28.57)
Very preterm	2 (1.92)	0	1 (14.29)
Extreme preterm	1 (0.96)	0	0
Unavailable	9 (8.65)	9 (9.28)	1 (14.29)

IQR = interquartile range.

found in between 11.7% and 46%.^{2,3,5,6,9,10} Some of the variation in this figure may well be caused by variation in practice over time and across locations, with a lower threshold for referral and further investigation resulting in a lower frequency of pathology.^{3,6} To reduce the number of unnecessary transfers, many studies have attempted to identify factors that could be used to predict a surgical diagnosis. Abdominal distension and tenderness, an abnormal abdominal x-ray, raised C-reactive protein, and age older than 72 hours have been shown to be associated with a surgical diagnosis.^{5,6} However, all are limited in their utility; for example, abdominal x-ray has been shown to have a sensitivity for surgical pathology of between 50% and 77%, making it unsuitable to exclude the possibility.^{3,6,9} In addition, these investigations may not be readily available at a rural hospital. Therefore, it remains difficult to exclude a surgical pathology at a peripheral hospital, necessitating transfer to a surgical center, and retrieval services will need to respond to these referrals in an appropriate time and with appropriate resources.

In our study, we found that 5.77% of infants had a time-critical pathology, which is again similar to previous studies that have found a risk of time-critical pathology of between 4.6% and 14.1%.^{2,3,5,6} Although abdominal tenderness, an abnormal abdominal x-ray, lower weight, and increasing day of life have been found to be associated with a time-critical pathology in some studies, this has not been replicated in others.^{2,5,6} In our study, we have shown a greater risk of time-critical pathology in those infants receiving cardiorespiratory support at the time of referral. However, there were 4 cases of time-critical pathology in infants who were subjectively well at the time of referral, which would support the conclusion of other studies that it is not possible to exclude a time-critical pathology at the peripheral hospital, and many have recommended that all referrals should be treated as time critical.^{2,4,5,7} Previous studies have shown that risk factors used in combination can improve their utility and the

inclusion of the need for cardiorespiratory support at the time of referral with other reported risk factors may help better identify infants at the greatest risk of time-critical pathology and reduce the overtriage of those who are not.⁵

To the best of our knowledge, this is the first study to report the risk of cardiorespiratory deterioration among retrieved infants with bilious vomiting, which we found to be 9.62%. All of these infants received at least 1 fluid bolus; however, none received vasoactive medications, and only 1 was intubated by the retrieval team. Retrieval services should consider the risk of cardiorespiratory deterioration, as well as the potential interventions that may be required to ensure safe transfer, when planning the composition of the team to be dispatched. As previously described, many retrieval services use nurse-led retrievals for noncritically ill children to facilitate timely transfer.² In infants not requiring interventions for cardiorespiratory support at the time of referral, we found a relatively low risk, 7.22%, of cardiorespiratory deterioration, and of those who did experience a deterioration, the vast majority did not require interventions beyond the administration of fluid boluses. Therefore, nurse-led, as opposed to physician- or advanced practitioner-led, retrieval of these infants may be appropriate, which could help facilitate timely transfer. However, retrieval services would need to consider appropriate mechanisms for escalation should the infant ultimately require interventions beyond the scope of practice of the team initially assigned.

This study represents the experience of only a single service, and variation in practice such as an individual clinician's threshold to refer an infant with bilious vomiting or initiate interventions for cardiorespiratory support would likely affect our outcomes of interest. In addition, the greater proportion of infants born before term in the group who had received interventions for cardiorespiratory support at the time of referral may be a potential confounding factor. Finally, the data were retrospectively collected and are therefore subject to the accuracy of the documentation at the time of the retrieval. Furthermore, multiservice studies could reduce the effect of variation in practice and may help better estimate the risk of surgical pathology, time-critical pathology, and cardiorespiratory deterioration in infants retrieved for bilious vomiting.

Conclusion

We found that among infants retrieved for bilious vomiting or aspirates approximately 1 in 5 had a surgical pathology, 1 in 17 had a time-critical pathology, and 1 in 10 experienced a cardiorespiratory deterioration during the retrieval. Infants receiving interventions for cardiorespiratory support at the time of referral were at a greater risk of time-critical pathology and cardiorespiratory deterioration during

Table 2
Range of Surgical Pathology

Surgical Pathology	Frequency, n (%)
Malrotation	5 (4.81)
Meconium ileus	3 (2.88)
Necrotizing enterocolitis	3 (2.88)
Hirschsprung's	2 (1.92)
Meconium plug	2 (1.92)
Anorectal malformation	2 (1.92)
Intestinal atresia	1 (0.96)
Spontaneous perforation	1 (0.96)
Intestinal infarction	1 (0.96)
Obstructive uropathy	1 (0.96)

Table 3
Outcomes

Outcome	Total (N = 104)	Infants Who Had Not Received Cardiorespiratory Support at the Time of Referral (n = 97)	Infants Who Had Received Cardiorespiratory Support at the Time of Referral (n = 7)	Risk Difference (95% CI)	Risk Ratio (95% CI)
Surgical pathology, n (%)	21 (21.91)	17 (17.53)	4 (57.14)		
Time-critical pathology, n (%)	6 (5.77)	4 (4.12)	2 (28.57)	24.45 (3.23–60.07)	6.93 (1.52–31.5)
Cardiorespiratory deterioration, n (%)	10 (9.62)	7 (7.22)	4 (57.14)	50.95 (18.17–78.19)	9.24 (3.38–25.27)

CI = confidence interval.

the retrieval than those who were not. These findings could inform the decision making of the retrieval service when planning team composition and timing of response for these referrals.

Declaration of competing interest

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CRediT authorship contribution statement

Jake Wright: Writing – review & editing, Writing – original draft, Visualization, Project administration, Methodology, Investigation, Formal analysis, Data curation, Conceptualization. **Bron Hennebry:** Writing – review & editing, Visualization, Project administration, Methodology, Conceptualization.

References

1. Burge DM. The management of bilious vomiting in the neonate. *Early Hum Dev.* 2016;102:41–45.

2. Nundeelesen S, Dalrymple H, Moustafa A, Thomas G, Carmo KB. How should the neonatal retrieval team respond to the neonate referred with bilious vomiting? *J Paediatr Child Health.* 2022;58:774–781.

3. Ojha S, Sand L, Ratnavel N, et al. Newborn infants with bilious vomiting: a national audit of neonatal transport services. *Arch Dis Child Fetal Neonatal Ed.* 2017;102:F515–F518.

4. Drewett M, Johal N, Keys C, J Hall N, Burge D. The burden of excluding malrotation in term neonates with bile stained vomiting. *Pediatr Surg Int.* 2016;32:483–486.

5. Mohinuddin S, Sakhuja P, Bermundo B, et al. Outcomes of full-term infants with bilious vomiting: observational study of a retrieved cohort. *Arch Dis Child.* 2015;100:14–17.

6. Cullis PS, Mullan E, Jackson A, Walker G. An audit of bilious vomiting in term neonates referred for pediatric surgical assessment: can we reduce unnecessary transfers? *J Pediatr Surg.* 2018;53:2123–2127.

7. Blackburn SC. Term newborns with bilious vomiting: when should they see a surgeon and how soon? *Arch Dis Child.* 2015;100:1–2.

8. Howson CP, Kinney MV, Lawn JE, et al. Born Too Soon: the Global Action Report on Preterm Birth, 2012, World Health Organization; Geneva. <https://iris.who.int/server/api/core/bitstreams/866b1af5-d81d-4398-ae5c-6e37e9abf972/content> (Accessed November 2, 2025)

9. Malhotra A, Lakkundi A, Carse E. Bilious vomiting in the newborn: 6 years data from a level III Centre. *J Paediatr Child Health.* 2010;46:259–261.

10. Godbole P, Stringer MD. Bilious vomiting in the newborn: how often is it pathologic? *J Pediatr Surg.* 2002;37:909–911.