Cardiology in the Young

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The utility of guaiac stool testing in the detection of gastrointestinal complications in infants with critical congenital heart disease

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Original Article

Cite this article: Muller M, Foster C, Lee J, Bauer C, Bor C, Buck L, Hicks F, Day J, Bagdure D, Holloway A, and Chaves A (2019) The utility of guaiac stool testing in the detection of gastrointestinal complications in infants with critical congenital heart disease. *Cardiology in the Young* **29**: 655–659. doi: 10.1017/S1047951119000659

Received: 17 August 2018
Revised: 25 January 2019
Accepted: 27 February 2019
First published online: 3 June 2019

Key words:
Necrotising enterocolitis; congenital heart disease; guaiac stools

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Abstract

Background: Guaiac stool testing has been routinely used as a method to detect gastrointestinal complications in infants with critical congenital heart disease (CHD); however, the sensitivity and specificity have not been established. *Methods:* A retrospective chart review was performed investigating the presence of heme-positive stools and subsequent gastrointestinal complications as well as time to goal caloric intake and radiograph exposure. *Results:* The presence of heme-positive stools was not a statistically significant factor in patients with critical CHD that experienced gastrointestinal complications. Additionally, patients with heme-positive stools did undergo more abdominal X-rays than those with heme-negative stools. *Conclusions:* The routine use of guaiac stool testing in infants with critical CHD is not a predictor of possible gastrointestinal complications and leads to more radiograph exposure for the patient. Close clinical monitoring can be used to evaluate feeding tolerance in infants with critical CHD.

Gastrointestinal complications are a significant problem in patients with critical congenital heart disease (CHD), including those with single ventricle physiology. These gastrointestinal complications lead to increased morbidity and mortality.[1,2] Infants with critical CHD are at a much higher risk of developing necrotising enterocolitis in particular because of a variety of aetiologies including impaired systemic blood flow; the stress of cardiac surgery and cardiopulmonary bypass; underlying baseline elevation of circulating cytokines; and diminished mesenteric flow during feedings.[3,4] Additional contributing factors include umbilical artery catheterisation as well as hypoxemia and hypotension.[3] While necrotising enterocolitis occurs more frequently in premature infants, approximately 10–15% of cases occur in full-term infants. It has been shown that critical CHD is a risk factor for full-term infants, with up to 25% of full-term infants with necrotising enterocolitis also having critical CHD.[5]

The most common presenting symptoms for necrotising enterocolitis among critical CHD patients are haematochezia and feeding intolerance.[3,6] Haematochezia in infants can be due to a diverse set of aetiologies. These aetiologies range from being relatively benign, including swallowed maternal blood or anal fissures, to severe causes such as necrotising enterocolitis. Other possibilities include milk protein allergy, the use of medications such as aspirin or ibuprofen, vitamin K deficiency, volvulus, or intussusception.[7] In the otherwise healthy infant, aetiologies are often benign. In infants with critical CHD, more serious causes such as necrotising enterocolitis need to be considered.

In infants with critical CHD, enteral feeding is introduced and titrated to goal caloric needs slowly to ensure feeding tolerance and minimise serious gastrointestinal complications. These patients are monitored for signs and symptoms of intolerance including emesis, abdominal distension, worsening somatic near-infrared spectroscopy values, occult blood, and haematochezia.[8] Guaiac testing of stools is often used to evaluate occult blood in stools.

The utility of guaiac testing of stools in this patient population is undetermined, as the test has the potential for false positives. In paediatric patients, minute blood loss can be associated with perianal dermatitis or passage of stool, which would yield a faecal blood-positive test and subsequent unnecessary diagnostic procedures.[9] In addition, studies have shown that the sensitivity, specificity, and positive predictive values of a positive faecal occult blood test among very low birth weight infants in the neonatal intensive-care unit were 0, 34.4, and 0%, respectively.[10] Due to the limited proven association between occult haematochezia and necrotising enterocolitis, some studies have found that routine faecal occult blood testing is not a useful

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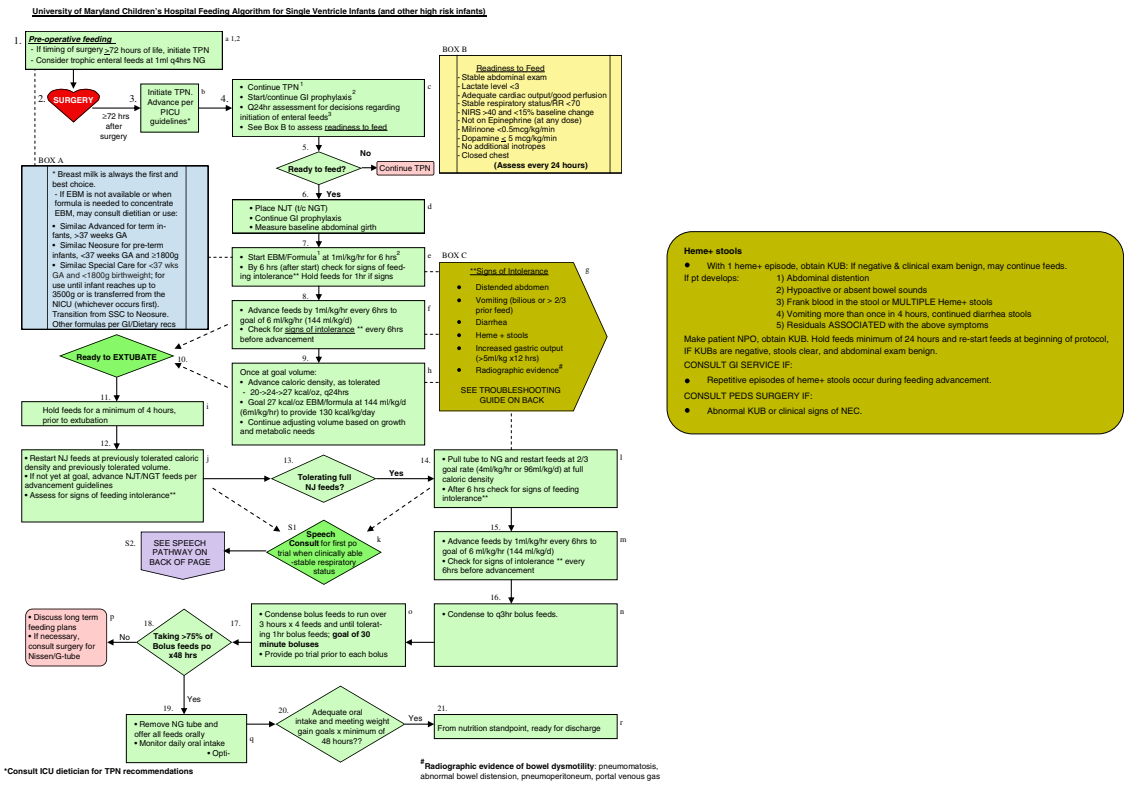

Figure 1. Feeding algorithm for single ventricle infants.

diagnostic tool for neonatal patients.[11,12] As a result, some centres have discontinued routine testing. Furthermore, Pinheiro et al,[11] hypothesised that false-positive faecal occult blood testing can have several adverse effects, including increased usage of radiographs and withholding feedings in patients who are already nutritionally compromised. Withholding feeds can negatively impact patient survival, growth, and development due to increased metabolic and infectious risks.[11,13]

Although the utility of guaiac testing is questioned by some, other literature indicates that occult blood can be indicative of serious gastrointestinal complications.[9] As such, some centres still conduct routine guaiac testing, particularly for patients at greater risk for life-threatening complications. In our tertiary care centre's paediatric cardiac surgery programme, our current feeding protocol involves routine guaiac testing of stools for infants with critical CHD who are receiving enteral feedings (Fig 1). We use guaiac testing to evaluate for potential feeding intolerance and serious gastrointestinal complications. When an infant has a guaiac-positive stool, enteral feedings are paused, and the patient receives an abdominal examination as well as an abdominal radiograph. Similar guaiac-positive stool protocols are considered common practice with enteral feedings, as shown in several study protocols[13,14] If the clinical exam and abdominal radiograph are benign, enteral feedings are resumed and the patient continues to be monitored for any further signs or symptoms of feeding intolerance and gastrointestinal complications.

While there is research on the utility of guaiac testing in neonates in general, there is a paucity of information in the literature discussing this practice of routine guaiac testing of stool in infants with critical CHD. Due to concerns regarding adverse effects of false-positive guaiac testing, we aimed to evaluate our use of guaiac testing of stools among patients with single ventricle physiology who underwent the stage one palliation for CHD. Specifically, we investigated the role of guaiac testing in detecting gastrointestinal complications, defined as a gastrointestinal surgical emergency or necrotising enterocolitis, as well as the association with feeding interruptions, time to achieving goal enteral feedings, placement of a gastrostomy tube, and frequency of radiographic exposure.

Material and methods

A retrospective chart review was performed on patients with single ventricle physiology who underwent stage one palliation (Norwood, Damus–Kaye–Stansel, or aortopulmonary shunt) at the University of Maryland Children's Hospital between 7 October, 2012, and 30 September, 2016 Patients were excluded from the analysis if their admission occurred prior to the initiation of the programme's single ventricle feeding protocol or if they were never able to achieve post-operative enteral nutrition. Patient characteristics are listed in Table 1.

Data were abstracted from electronic and paper medical records. Baseline demographic data included gender, birth length and weight, gestational age, cardiac diagnosis (classified as hypoplastic left heart syndrome, other single right ventricle, tricuspid atresia, pulmonary atresia with intact ventricular septum, double inlet left ventricle, or other single left ventricle), genetic syndromes, gastrointestinal abnormalities, other comorbidities, and type of feeds received preoperatively. Surgical data included type of stage one palliation surgery (Norwood/Damus–Kaye–Stansel or aortopulmonary shunt), age at surgery, cardiopulmonary bypass time, cross-clamp time, and surgical complications. Post-surgical information included history of cardiac arrest, need for extracorporeal mechanical oxygenation, post-operative duration of intubation,

https://doi.org/10.1017/S1047951119000659 Published online by Cambridge University Press

Table 1. Patient characteristics (n = 19)

Female gender (%)	9 (47.4)
Diagnosis (%)	
HLHS	7 (36.8)
Other single RV	3 (15.8)
Tricuspid atresia	3 (15.8)
PA/IVS	2 (10.5)
Other single LV	4 (21.1)
Surgery (%)	
Norwood with Sano shunt	9 (47.4)
Aortopulmonary shunt	10 (52.6)
Genetic syndrome (%)	6 (31.6)
Use of ECMO or cardiac arrest after surgery (%)	2 (10.5)
Delayed sternal closure (%)	11 (57.9)
Repeat surgery or post-operative cardiac catheterisation (%)	7 (36.8)
Intubated for more than 1 week (%)	6 (31.6)
Pre-operative feeds (%)	8 (42.1)
Vocal cord dysfunction (%)	3 (15.8)
Aspiration (by UGI study) (%)	6 (31.6)
Birth weight, kg (SD)	2.86 (0.73)
Birth WAZ (SD)	−0.03 (1.09)
Birth length, cm (SD)	48 (3.83)
Birth LAZ (SD)	−0.36 (1.12)
Gestational age, weeks (SD)	39 (2.37)
Age at surgery, days (SD)	4 (18.5)

ECMO = extracorporeal membrane oxygenation; HLHS = hypoplastic left heart syndrome; LAZ = length for age z score; LV = left ventricle; PA/IVS = pulmonary atresia with intact ventricular septum; RV = right ventricle; UGI = upper gastrointestinal; WAZ = weight for age z score.
Continuous data are presented as medians with standard deviation.

need for reintubation, need for repeat surgeries, or cardiac catheterisation (excluding delayed sternal closure), delayed sternal closure, number of days on inotrope or vasopressor support, multiple guaiac-positive stools, vocal cord dysfunction, or chylothorax). The presence or absence of heme-positive stools was evaluated, as well as time (in days) to goal caloric intake, presence or absence of serious gastrointestinal complication (defined as a gastrointestinal surgical emergency or necrotising enterocolitis), placement of a gastrostomy tube, and number of abdominal radiographs performed on each patient.

Results

There were 19 patients included in this analysis. During hospitalisation, 12 out of the 19 (63%) patients experienced heme-positive stools. The median days to goal caloric intake (n = 19) was 6 days (IQR = 7). Days to goal caloric intake for the heme-positive group (mdn = 5, IQR = 8) was not significantly different (U = 43.5, p = 0.967) compared to the heme-negative group (mdn = 7, IQR = 9). The data for days to goal caloric intake were not normally distributed and a Mann–Whitney U-test was used to compare days to goal caloric intake for patients with and without heme-positive stools.

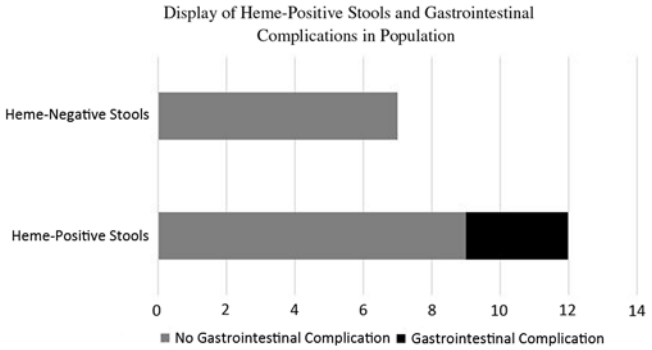

Figure 2. Display of results of haemoccult stool tests and patients with gastrointestinal complications.

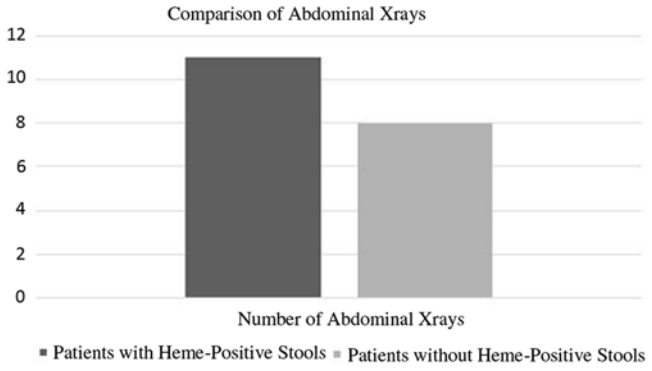

Figure 3. Comparison of abdominal radiographs in patients with and without heme-positive stools.

During the study period, 3 out of the 19 patients had a serious gastrointestinal complication (Fig 2). There was no statistically significant difference (p = 0.117) in the proportion of heme-positive and heme-negative stools between patients with and without a serious gastrointestinal complication. Those patients with serious gastrointestinal complication also experienced grossly bloody stools, had a diagnosis of medical necrotising enterocolitis, or had an abdominal radiograph showing dilated bowel loops. In the study, 12 out of 19 patients required placement of a gastrostomy tube. There was no statistically significant difference (p = 0.356) in the heme-positive and heme-negative stool proportion between patients who did and did not require a gastrostomy tube. Given the sample size, and because expected frequencies were small, a Fisher's exact test was used to compare both serious gastrointestinal complications and gastrostomy tube placements between patients with and without heme-positive stools.

The number of abdominal radiographs performed for each patient was collected for patients with and without guaiac-positive stools. These numbers were evaluated using a Mann–Whitney U-test. A p value less than 0.05 was used for statistical significance. Analysis revealed significant difference in the number of abdominal radiographs for patients with heme-positive stools (Md = 4, n = 11) and patients without heme-positive stools (Md = 0, n = 8), U = 6, z = −3.187, p = 0.001, r = 0.73 (Fig 3).

https://doi.org/10.1017/S1047951119000659 Published online by Cambridge University Press

https://doi.org/10.1017/S1047951119000659 Published online by Cambridge University Press

Table 2. Detailed diagnosis and medical information for patients that experienced heme-positive stools.

Patient	Diagnosis	Surgical palliation	Post-operative complications	Abnormal ECHO findings	EDP (dominant ventricle) mmHg	Interventions performed during cardiac catheterisation	Anti-coagulation therapy	Number of feed interruptions (>6 hours)	Total number of AXRs	Discharge feeding route	Indication for GT	GI complications	GI surgeries
1	TA	BT shunt	Superficial SSI	None	14	None	ASA	1	2	NG to rehab facility			
2	Other single LV	Central shunt	Chylothorax	None	6	None	ASA	6	>10	PO/GT	Aspiration on MBS	Allergic colitis	Flexible sigmoidcoscopy
3	HLHS	Norwood with Sano shunt	DSC, Left haemidiaphragm paresis, SSI	Mod TR, mild RV dysfunction, gradient through aortic arch with balloon dilation of arch	9	Balloon dilation of aortic arch	ASA	7	>10	GT	Oromotor dysfunction		
4	Other single RV	BT shunt	Superficial SSI, SVC thrombus	None	7	None	Enoxaparin	1	4	NG to rehab facility			
5	TA	BT shunt	None	LPA stenosis with balloon dilation and stent placement	No data	No data	ASA	1	4	PO			
6	Other single RV	BT shunt	Shunt thrombus with thrombectomy and Revision, DSC, SSI	None	10	None	ASA	0	3	PO			
7	HLHS	Norwood with Sano shunt	DSC, superficial SSI, left vocal cord paresis	None	10	None	ASA	2	4	GT	Aspiration on MBS		
8	HLHS	Norwood with Sano shunt	DSC	Aortic arch narrowing with balloon dilation	10	Balloon angioplasty of neo-aortic arch	ASA	9	>10	GT	Oromotor dysfunction	Multiple episodes of medical NEC	
9	Other single RV	BT shunt	DSC, acute shunt thrombosis, cardiac arrest, BT shunt stent placement	None	No data	No data	ASA	4	>10	GJT	Placed during abdominal surgery	Volvulus, malrotation	Exploratory laparoscopy and Ladd's procedure
10	PA/IVS	BT shunt	Enterococcus bacteremia	None	10	None	ASA	0	3	PO			
11	HLHS	Norwood with Sano shunt	DSC, left haemidiaphragm paresis, left vocal cord dysfunction	None	8	None	ASA	1	3	GT	Oromotor dysfunction, vocal cord dysfunction		

ASA = aspirin; AXR = abdominal radiograph; BT = Blalock–Taussig; DSC = delayed sternal closure; EDP = end diastolic pressure; GI = gastrointestinal; GJT = gastro-jejunal tube; GT = gastrostomy tube; HLHS = hypoplastic left heart syndrome; LPA = left pulmonary artery; LV = left ventricle; MBS = modified barium swallow study; NEC = nectrotising enterocolitis; NG = nasogastric; PA/IVS = pulmonary atresia with intact ventricular septum; PO = by mouth; RV = right ventricle; SSI = surgical site infection; SVC = superior caval vein; TA = triscuspid atresia; TR = tricuspid regurgitation.

Discussion

In our study, 11 out of 19 (58%) patients experienced haemoccult-positive stools during their post-operative course. Details for these patients are included in Table 2. Heme-positive stools were not found to increase time to achieve full enteral nutrition. Thus, although some literature asserts that heme-positive stools do not justify withholding feedings, doing so did not delay time to achieving full enteral nutrition.[15] In addition, heme-positive stools were not found to correlate with increased frequency of gastrointestinal emergencies, including necrotising enterocolitis. This is supported by other studies that found that there is limited association between occult haematochezia and necrotising enterocolitis, and thus limited utility of routine faecal occult blood testing in infants.[10–12] Although there is no correlation between heme-positive stools and increased incidence of gastrointestinal emergencies, there were no gastrointestinal emergencies in the patients with heme-negative stools in our study.

Our study did show that there was an association between heme-positive stools and an increased number of abdominal radiographs. Increased abdominal radiograph in children has been associated with an increased cumulative cancer lifetime mortality risk.[16] Given that the presence of heme-positive stools did result in an increased number of abdominal radiographs but did not result in an increased detection of gastrointestinal emergencies, haemoccult testing does not seem to be a valuable diagnostic tool and may place the patient at increased risk of radiation exposure. This is supported by the results of additional studies that assert that there are no advantages to routine guaiac testing of stool in the absence of other indicators for feeding intolerance or gastrointestinal complications, such as emesis, abdominal distension, and gastric residuals.[17]

There are several limitations to this study. Due to our specific population, the sample size is small and thus limits the generalisability of our findings. Also, since this was a retrospective chart review over several years, there could have been some variability in documentation of procedures over time, leading to misclassification bias. Moreover, our study population is heterogeneous with various diagnoses and post-operative courses, and thus a few outliers could have disproportionally affected the measures we investigated. Despite these limitations, this study serves as an initial evaluation of the utility of guaiac testing in critical CHD patients, which is a little-researched field. More research needs to be done in this field with larger sample sizes to further investigate our findings.

Conclusion

Infants with critical CHD are at a heightened risk of having gastrointestinal complications while advancing feeds. Current practice utilises routine guaiac stool testing as a marker for gastrointestinal complications. Our results show that heme-positive stools are not associated with gastrointestinal complications in this population, but they are associated with an increased number of abdominal radiographs. This suggests that routine guaiac testing is of low yield in detecting problems and may lead to evaluations that place our patients at future risk.

Acknowledgements. None.

Financial Support. This research received no specific grant from any funding agency, commercial or not-for-profit sectors.

Conflicts of Interest. None.

References

1. Golbus JR, Wojcik BM, Charpie JR, Hirsch JC. Feeding complications in hypoplastic left heart syndrome after the Norwood procedure: a systematic review of the literature. Pediatr Cardiol 2011; 32: 539–552. doi: 10.1007/s00246-011-9907-x.
2. Jeffries HE, Wells WJ, Starnes VA, Wetzel RC, Moromisato DY. Gastrointestinal morbidity after norwood palliation for hypoplastic left heart syndrome. Ann Thorac Surg 2006; 81: 982–987. doi: 10.1016/j.athoracsur.2005.09.001.
3. Giannone PJ, Luce WA, Nankervis CA, Hoffman TM, Wold LE. Necrotizing enterocolitis in neonates with congenital heart disease. Life Sci 2008; 82: 341–347. doi: 10.1016/j.lfs.2007.09.036.
4. McElhinney DB, Hedrick HL, Bush DM, et al. Necrotizing enterocolitis in neonates with congenital heart disease: risk factors and outcomes. Pediatrics 2000; 106: 1080–1087. doi: 10.1542/peds.106.5.1080.
5. Ostlie DJ, Spilde TL, St Peter SD, et al. Necrotizing enterocolitis in full-term infants. J Pediatr Surg 2003; 38: 1039–1042. doi: 10.1016/S0022-3468(03)00187-8.
6. Hunter CJ, Podd B, Ford HR, Camerini V. Evidence vs experience in neonatal practices in necrotizing enterocolitis. J Perinatol 2008; 28: S9–S13. doi: 10.1038/jp.2008.43.
7. Pai AK, Fox VL. Gastrointestinal bleeding and management. Pediatr Clin 2017; 64: 543–561. doi: 10.1016/j.pcl.2017.01.014.
8. Sharma R, Hudak ML. A clinical perspective of necrotizing enterocolitis: past, present, and future. Clin Perinatol 2013; 40: 27–51. doi: 10.1016/j.clp.2012.12.012.
9. Boyle JT. Gastrointestinal bleeding in infants and children. Pediatr Rev 2008; 29: 39–52. doi: 10.1542/pir.29-2-39.
10. Pickering A, White R, Davis NL. Routine fecal occult blood testing does not predict necrotizing enterocolitis in very low birth weight neonates. J Neonatal Perinatal Med 2016; 9: 171–178. doi: 10.3233/NPM-16915120.
11. Pinheiro JMB, Clark DA, Benjamin KG. A critical analysis of the routine testing of newborn stools for occult blood and reducing substances. Adv Neonatal Care 2003; 3: 133–138. doi: 10.1016/S1536-0903(03)00073-0.
12. Abramo TJ, Evans JS, Kokomoor FW, Kantak AD. Occult blood in stools and necrotizing enterocolitis: is there a relationship? Am J Dis Child 1988; 142: 451–452. doi: 10.1001/archpedi.1988.02150040105030.
13. Krishnamurthy S, Gupta P, Debnath S, Gomber S. Slow versus rapid enteral feeding advancement in preterm newborn infants 1000-1499 g: a randomized controlled trial. Acta Paediatr Int J Paediatr 2010; 99: 42–46. doi: 10.1111/j.1651-2227.2009.01519.x.
14. Caple J, Armentrout D, Huseby V, et al. Randomized, controlled trial of slow versus rapid feeding volume advancement in preterm infants. Pediatrics 2004; 114: 1597–1600. http://pediatrics.aappublications.org/content/114/6/1597.abstract.
15. Stiles AD, Simpson B, Vaughn R, Thullen JT. Incidence of heme positive stools in a neonatal intensive care unit. Pediatr Res 1984; 18: 350A. doi: 10.1203/00006450-198404001-01542.
16. Baird R, Tessier R, Guilbault M-P, Puligandla P, Saint-Martin C. Imaging, radiation exposure, and attributable cancer risk for neonates with necrotizing enterocolitis. J Pediatr Surg 2013; 48: 1000–1005. doi: 10.1016/j.jpedsurg.2013.02.016.
17. Carter BM. Nursing assessment of guaiac-positive and occult blood in preterm infant stools. Neonatal Netw J Neonatal Nurs 2014; 33: 101–105. doi: 10.1891/0730-0832.33.2.101.

https://doi.org/10.1017/S1047951119000659 Published online by Cambridge University Press