

Iodinated Contrast-Induced Hypothyroidism in An Infant after Enteral Contrast Enema: A Case-Report and Systematic Review

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What is already known on this topic?

Data on the effects of iodinated contrast media (ICM) on thyroid function in children is scarce. After the Food and Drug Administration warning on the use of ICM in 2022, this topic has attracted more attention. Most recent studies have focused on the effect of topical or intravascular administration of ICM on thyroid function. However, data about the effect of enteral ICM administration on thyroid function are lacking.

What this study adds?

This is the first study to provide a systematic review of the current literature on enteral ICM-induced hypothyroidism in infants. The case-report and overview of the available literature highlights the potential severity of this iatrogenic hypothyroidism and suggests that future studies and clinical guidelines on this specific topic would be beneficial.

Abstract

Excessive iodine intake may trigger the Wolff-Chaikoff effect, which results in downregulation of thyroid hormone synthesis to prevent hyperthyroidism. Failure to recover euthyroidism after the Wolff-Chaikoff effect may be seen in infants, and especially premature infants, and may result in prolonged iodine-induced hypothyroidism. We describe a rare case of a preterm infant who developed severe iodinated contrast-induced hypothyroidism after the use and prolonged stasis of enteral iodinated contrast media (ICM). In addition, a systematic literature search was performed to evaluate all available data on this condition. This systematic literature search was performed in

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PubMed and Embase. Studies describing the effect of enteral ICM on thyroid function were considered eligible. The primary outcome was to determine the frequency of contrast-induced hypothyroidism in infants after administration of enteral ICM. The premature infant in our center developed severe iodinated contrast-induced hypothyroidism after enteral ICM. In total, only two studies met our eligibility data, reporting eight patients. Of these eight patients, four premature infants developed contrast-induced hypothyroidism after enteral administration of ICM. Data on severity, length and frequency of contrast-induced hypothyroidism after exposure to enteral ICM is very scarce. The present case-report and literature search highlights the potential severity of this iatrogenic hypothyroidism and suggests that future studies and clinical guidelines on this specific topic would be beneficial. We recommend standardized monitoring of thyroid function after exposure to enteral ICM in newborns to prevent delayed diagnosis of severe contrast-induced hypothyroidism until evidence based recommendations can be made.

Keywords: Hypothyroidism, iodinated contrast media, contrast induced hypothyroidism.

Introduction

Thyroid hormones are essential in fetal intrauterine and neonatal postnatal brain development, growth and metabolism (1). Untreated persistent neonatal hypothyroidism can cause serious brain damage, including mental retardation and impaired motor function (1). Therefore, newborn screening (NBS) programs for congenital hypothyroidism (CH) are in place to detect thyroid dysfunction as early as possible in life and to prevent brain damage by timely start of levothyroxine treatment (2). Depending on the type of NBS program, only primary CH, or primary and central CH may be diagnosed. Primary CH is caused by abnormal thyroid gland development or thyroid hormone biosynthesis, with an estimated incidence of 1:3000-4000 live births (3).

Acquired hypothyroidism in the neonatal period is rare. One of its potential causes is the excessive exposure to iodine via the skin (disinfectants/antiseptics containing iodine), gastrointestinal tract or intravenously (iodinated contrast medium; ICM) (4,5,6,7). Iodine is crucial for thyroid hormone synthesis. Many radiological diagnostic procedures involve ICM, resulting in potential excessive iodine exposure to the thyroid gland. Physiologically, the thyroid responds with downregulation of thyroid hormone synthesis to prevent hyperthyroidism, a phenomenon called the Wolff-Chaikoff effect (8). After a few days, escape from the Wolff-Chaikoff effect should occur, resulting in normalization of thyroid hormone synthesis. However, failure to escape the effect may result in prolonged hypothyroidism. Previous studies have shown that both topical and intravenous ICM administration may cause transient thyroid dysfunction, particularly in preterm infants as a result of a failed escape from the Wolff-Chaikoff effect (9,10,11). It is thought that prematurity is a risk factor for prolonged hypothyroidism after exposure to ICM because of immaturity of the escape mechanism (12). Especially during the neonatal period, when brain development is dependent on sufficient thyroid hormone concentrations, prolonged hypothyroidism should be prevented.

In 2022, the United States Food and Drug Administration (FDA) released a medication safety communication recommending thyroid function evaluation for children under the age of three years within three weeks after intravascular administration of ICM (12). The FDA statement resulted in increased attention to this subject. Subsequently, the Pediatric Endocrine Society (PES) and American College of Radiology (ACR) published statements questioning this recommendation due to lack of evidence and proposed a more individualized approach, identifying high-risk patient groups, like premature newborns (2,5). The current recommendations address intravenous ICM administration and overlook enteral ICM administration. Here we describe a case of prolonged hypothyroidism in a premature infant after enteral ICM exposure, and summarize the results of a systematic literature study into the reported number of cases of contrast-induced hypothyroidism in infants after enteral ICM administration.

Methods

A literature study was conducted according to the preferred reporting items for systematic reviews and meta-analysis guidelines (available at <https://www.prisma-statement.org>). In accordance with the guidelines, our systematic review protocol was registered in the international prospective register of systematic reviews with the number CRD42023393923. Informed consent was obtained for publication from parents of the patient that is described in the case-report. The Medical Ethics Review Committee of Amsterdam University Medical Centers is registered with the US Office for Human Research Protections as IRB00013752. The FWA number assigned to Amsterdam UMC is FWA00032965.

Literature Search

All scientific publications reporting on enteral ICM administration in newborns were considered eligible for review. A medical information specialist (RdV) searched electronic databases (PubMed and EmBase) from inception to

January 23, 2023. The following terms were used (including synonyms and closely related words) as index terms or free-text words: Iodinated contrast media, “Thyroid function”, “Hypothyroidism” and “Neonates”. Language restrictions were not applied and duplicates were excluded by RvD using Endnote X20.0.1 (Clarivate™), following the Amsterdam Efficient Deduplication and Bramer-methods (13). Studies were screened by two independent authors using Rayyan (LDES, AGHP) (14). Full texts of the selected articles were retrieved for further review. Any disagreements were resolved by consultation with an expert specialist (JPMD). The reference lists of included articles were reviewed for additional relevant studies. Inclusion criteria were pediatric patients under the age of one year, enteral administered ICM and clearly described follow-up of thyroid function. Animal studies, duplicates, conference abstracts, studies reporting on intravenous or topical ICM administration and previous published data were excluded. The full search strategies for all databases are available as Supplementary Material 1.

Primary Outcome

The primary outcome was to determine the reported number of cases of contrast-induced hypothyroidism in infants after enteral administration of ICM. This outcome was illustrated with a case-report from our own center.

Data Extraction and Validity Assessment

Two authors (LDES, AGHP) independently extracted the data, and evaluated the methodological quality and risk of bias. Disagreements were resolved through discussion; if no consensus could be reached, a third reviewer was consulted (JPMD).

All included articles were assessed for methodological quality and risk of bias using the Joanna Briggs Institute (JBI) Critical Appraisal Checklist for Case-reports, Case series and cohort studies (15). For each tool several questions regarding

methodological quality of the study need to be answered with “Yes”, “No”, “Unclear” or “Not applicable”. Each answer option was scored and summed up. The maximum score for case-reports was 24 points. “High” quality was defined as 19 points or higher, “Moderate” as 14 to 18 points, and “Low” as 13 points or lower. For case series the maximum score was 30 points. “High” quality was defined as 24 points or higher, “Moderate” as 17 to 23, and “Low” as 16 points or less. Publications scored as “high” or “moderate” quality were included in this systematic review.

Statistical Analysis

Statistical meta-analysis of data obtained in the systematic review was not performed due to the low number of included articles.

Results

1. Case-report

The patient is a girl, born small for gestational age through Cesarean section at gestational age of 26⁶/₇ weeks (birthweight 550 g, Z-score -1.7) (16). The pregnancy was complicated by fetal growth restriction due to placental insufficiency. Prenatal fetal ultrasound revealed dilated intestinal loops. The first weeks of life were complicated by multiple gastro-intestinal problems including meconium plug requiring ileostomy creation on day 2 (D2), and a jejunal intestinal perforation on D6 for which surgery was performed with overstitching of the perforation (Figure 1). Postoperatively, on D8 minimal enteral feeding was started. However, an increase in feeding volumes resulted in a high-output stoma. In addition, failure to grow and difficulties with distal stoma refeeding were observed. A fistulogram was performed on D79 using 20 mL of omnipaque (240 mg I/mL) to visualize the distal bowel patency, showing no stenosis, obstruction or dilated bowel loops (Figure 2A).

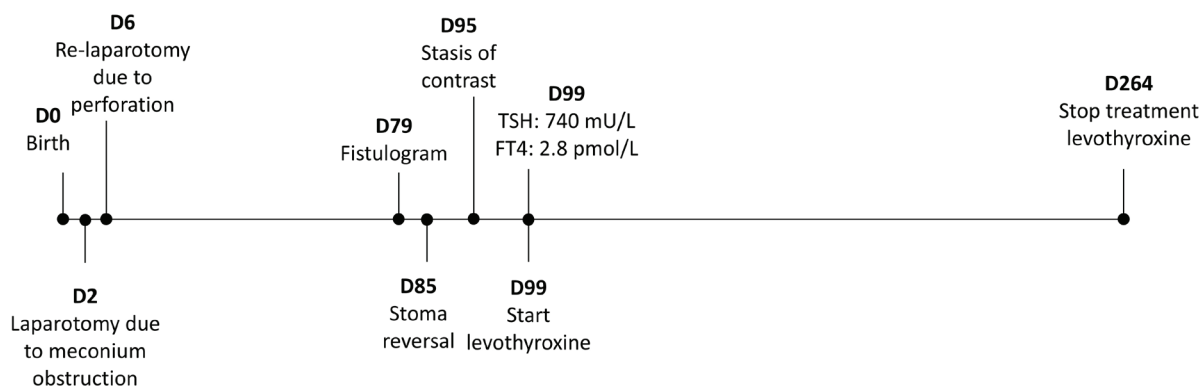


Figure 1. Timeline of a neonatal patient who developed iodinated contrast induced hypothyroidism

TSH: thyroid-stimulating hormone, fT4: free thyroxine

Surgical stoma reversal was done on D85. Postoperatively, bilious retentions persisted and there was no defecation. The patient developed a severe systemic inflammatory response syndrome (SIRS), resulting in respiratory insufficiency requiring high respiratory pressures, hypotension, electrolyte imbalances, and extreme soft tissue edemas necessitating circulatory support (Figure 2B). The chest X-ray on D95 showed ICM stasis in the rectum (Figure 2C). Rectal irrigation was started on D98 due to constipation. On D98 a chest X-ray was taken to check for pulmonary abnormalities, showing signs of osteopenia (Figure 2D). With no clear cause for the clinical deterioration, the pediatric endocrinologist was consulted regarding the osteopenia and suspicion of adrenal insufficiency as a possible cause of the circulatory insufficiency. Central adrenal insufficiency

was ruled out via a low-dose cosyntropin stimulation test. Additional endocrinological laboratory test on D99 revealed severe primary hypothyroidism with an extremely elevated thyroid-stimulating hormone (TSH) level of 740 mU/L (local age-specific reference range 0.7-8.4 mU/L) and very low free thyroxine (fT4) level of 2.8 pmol/L (local age-specific reference range 11.9-25.6 pmol/L). Prior to this, the NBS result for CH was normal, as were previous thyroid function tests (fT4 concentration 15.0 pmol/L at D58). Treatment with levothyroxine was started immediately (D99) at a daily dose of 25 mcg (6.62 mcg/kg/day). Within two days after start of levothyroxine treatment, circulatory and respiratory status improved and treatment with inotropic drugs could be stopped. During follow-up, levothyroxine dose was titrated based on thyroid function testing. At D264 levothyroxine treatment could be stopped with normal thyroid function at further follow-up.

The girl's primary hypothyroidism was thought to be acquired, especially because of the normal fT4 concentration on D58. In retrospect, the ICM administered on D79 was still visible on the chest X-ray on D95, indicating gastrointestinal stasis of ICM for 19 days. This prolonged exposure to ICM was judged to be the most likely cause of the hypothyroidism. Since iodine-induced hypothyroidism is almost always a transient problem, that the thyroid function remained normal after stopping levothyroxine treatment is further proof for this diagnosis.

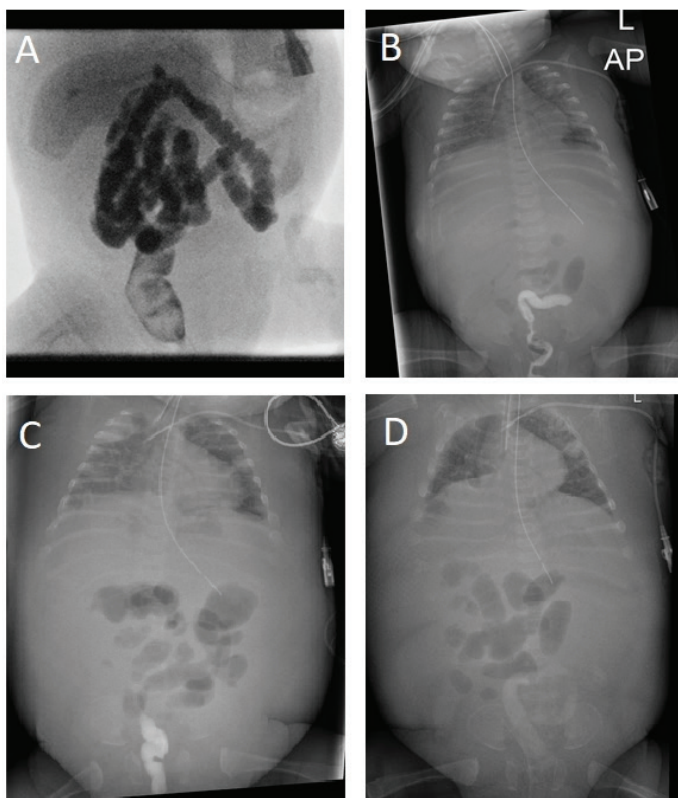


Figure 2. Radiological images of a neonatal patient who developed iodinated contrast induced hypothyroidism. **A)** D79, fistulogram. Contrast enema omnipaque 240 mg I/mL, 20 mL administered via the ileostomy. Normal diameter and appearance of the bowel loops and colon. **B)** D86, X-ray of the thorax and abdomen. Seven days after contrast enema. Pulmonary markings that indicate bronchopulmonary dysplasia. Distended abdomen, with abnormal bowel gas, and residual intraluminal contrast in the distal recto sigmoid. Edematous soft tissue. **C)** D95, X-ray of the thorax and abdomen. Sixteen days after contrast enema, intraluminal contrast is still visible. **D)** D98, X-ray of the thorax and abdomen. Nineteen days after contrast enema. This was after rectal irrigation and only subtle appearance of intraluminal contrast is visible

2. Systematic Review

The systematic literature search in PubMed and Embase resulted in 2012 unique articles. After title and abstract screening 1984 articles were excluded. The remaining 28 articles underwent full-text screening, resulting in exclusion of 26 articles. Reasons for exclusion were intravenous contrast administration ($n = 12$), topical povidone use ($n = 4$), studies without original data ($n = 9$), and incomplete information ($n = 1$). Ultimately, two studies were included, reporting eight patients with thyroid function follow-up after exposure to enteral ICM (Figure 3). Study characteristics are summarized in Table 1 (17,18).

Risk of Bias

Risk of bias was assessed using the JBI Critical Appraisal Checklist for case-reports, case series and cohort studies (15). Results are shown as Supplementary Material 2. The quality of the case-report by Lombard et al. (18) was scored as high and the case series of Ares et al. (17) was scored as moderate.

Study Characteristics of Contrast Induced Hypothyroidism

The two eligible studies, published in 2008 and 2009, included one case-series and one case-report. The case series of Ares et al. (17) described seven newborns from a neonatology department during a one-year period. The infants received Gastrografin, a contrast enema with an iodine concentration of 370 mg/mL. The indication for Gastrografin administration was treatment for uncomplicated meconium ileus in three patients, and use as contrast medium for

radiological imaging in four patients. All had normal NBS results for CH. Six out of seven patients were born preterm (range 27-36 weeks gestational age). Hypothyroidism was defined as increased TSH levels (local reference range 0.5-6.15 mU/L) and normal to decreased fT4 levels (local reference range 0.70-1.64 µg/dL). Normal total T4 levels were defined as >6.5 µg/dL. Three of the seven reported patients developed contrast-induced hypothyroidism (Table 1). All three patients with hypothyroidism were born premature. The first diagnosed patient was treated with Gastrografin for meconium ileus, exhibiting elevated TSH levels and decreased fT4 levels on D6 after administration. In the second case, Gastrografin was administered as contrast enema, resulting in increased TSH and normal fT4 levels observed 13 days later. In the third case, Gastrografin was administered as contrast medium. TSH levels were increased, but the total T4 level was elevated. The duration between Gastrografin administration and thyroid function evaluation was not specified. The three infants diagnosed with contrast-induced hypothyroidism were all treated with levothyroxine for one month after which levothyroxine treatment was stopped. In one patient the TSH level was high after cessation of levothyroxine treatment resulting in restarting levothyroxine treatment and further follow-up by a pediatric endocrinologist. In summary, Ares et al. (17) reported that three out of seven infants who received Gastrografin, all premature born, were diagnosed with, and treated for iodine-induced hypothyroidism.

Lombard et al. (18) reported a case of a male infant, born at 27 weeks gestation. Due to failure to pass stools, he underwent a diagnostic test receiving a sodium ioxitalamate contrast enema with an iodine concentration of 120 mg/mL with a total volume of less than 20 mL. After 23 days the male infant developed jaundice and biochemical evaluation showed cholestasis. Sixty-six days after contrast administration thyroid function was evaluated because of

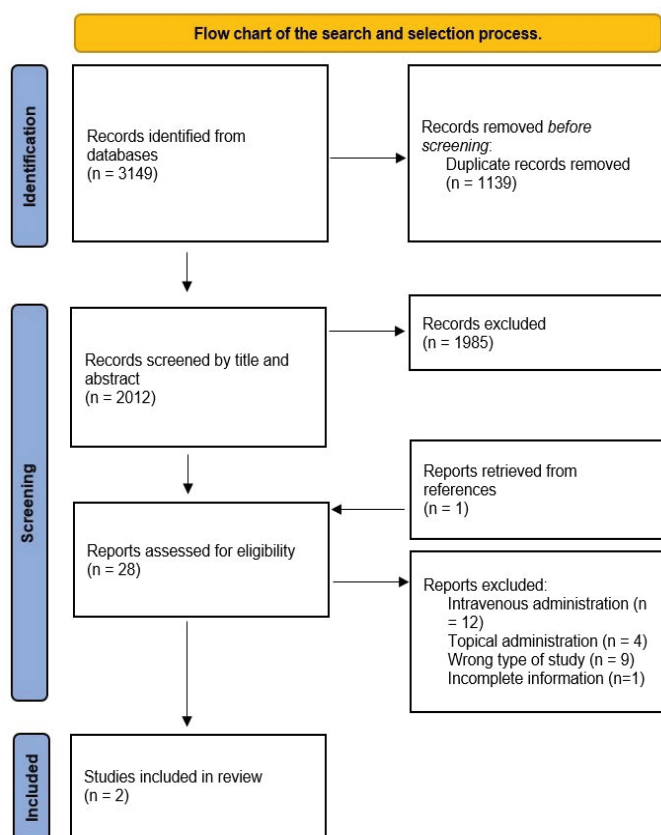


Figure 3. Flowchart of search and selection process

Table 1. Included studies in this systematic review on contrast induced hypothyroidism in neonates

Author	Year	Type of study	Premature	CIH	Type of contrast	Reason for use of iodinated enteral contrast	Laboratory values	Treatment levothyroxine
Ares et al. (17)	2008	Case-series	6/7, range 27-36 weeks GA	3/7	Gastrografin	Treatment uncomplicated meconium obstruction (n = 3) Radiological imaging (n = 4)	Case 1 TSH: 33.14 µUI/mL fT4: 0.51 µg/dL Case 2 TSH: 25.7 µUI/mL fT4: 1.06 µg/dL Case 3 TSH: 40.0 µUI/mL total T4: 3.4 µg/dL	3/7
Lombard et al. (18)	2009	Case-report	1/1, 27 weeks GA	1/1	Ioxitalamate (telebrix 12)	Meconium obstruction (n = 1)	TSH: 368 µUI/mL (local reference range 0.2-4.2 µUI/mL), fT4: 5.1 pg/mL (local reference range 9.3-17.0 pg/mL) fT3: 2 pg/mL (local reference 1.5-4.1 pg/mL)	1/1

TSH: thyroid-stimulating hormone, fT4: free thyroxine, GA: gestational age, CIH: contrast induced hypothyroidism

persistent cholestasis. Contrast induced hypothyroidism was diagnosed based on elevated TSH, decreased fT4 and normal fT3 levels (Table 1). Treatment with levothyroxine was started immediately. After 49 days treatment could be stopped, and TSH, fT4 and fT3 levels remained normal.

In total, four of the eight reported patients who received enteral ICM were diagnosed with contrast-induced hypothyroidism. The patients with reported iodinated contrast induced hypothyroidism were all born premature.

Discussion

We present a case of a preterm infant who developed iodine-induced hypothyroidism after enteral ICM administration via a fistulogram, followed by prolonged stasis of the ICM. Within twenty days after ICM administration the patient developed severe SIRS. Laboratory results showed an extremely elevated TSH level and a very low fT4, indicating severe primary hypothyroidism. Although it is uncertain whether the clinical symptoms prior to levothyroxine treatment were only caused by severe hypothyroidism, the patient recovered rapidly after initiation of treatment with levothyroxine. A systematic literature search was performed to evaluate this complication of enteral ICM. Only two studies reported on iodine-induced hypothyroidism after enteral ICM administration, including eight patients of whom four were diagnosed with ICM-induced hypothyroidism.

The FDA released a medication safety communication in March 2022 advising thyroid function monitoring within three weeks following intravascular administration of ICM in all children under the age of three years (12). This caution is rooted in the fact that especially infants are vulnerable to thyroid dysfunction after excessive intake of iodine, resulting in the Wolff-Chaikoff effect (8). The escape from the inhibitory impact of high iodine dosages, however, is not always successful in infants, and may cause clinical or subclinical hypothyroidism (19). It is thought that preterm infants might be especially at risk of developing ICM-induced hypothyroidism since the ability to escape from the Wolff-Chaikoff effect develops only between 36 and 40 weeks of gestation (20,21). Effects of ICM administration on thyroid function in children have therefore been a topic of debate in recent literature. Available literature primarily focused on intravenous administration, for example for cardiac interventions and evaluation of tip position of peripherally inserted central catheter or topical administration for disinfection (4,9,22). The results of these studies are contradictory and randomized studies with large sample sizes are lacking. The results of our systematic literature search showed that evidence on the effects of the use of

enteral ICM on thyroid function in (premature) infants is limited. Nevertheless, it is important to raise awareness for the potential severe clinical consequences of late diagnosis of iodine-induced hypothyroidism after prolonged exposure to enteral ICM, as illustrated by our patient.

In patients with CH it is known that persistent low thyroid hormone concentrations have a major negative impact on brain development. Over recent decades, more and more countries have introduced NBS for CH. Since then, numerous studies have sought to compare the IQ scores of patients treated for CH with those who received no treatment. The benefits of early detection and treatment are indisputable from these studies (23,24). Notably, subsequent studies have found that the severity of hypothyroidism plays a significant role in the neurological outcome of these patients (3). In cases with acquired hypothyroidism, such as patients with contrast-induced hypothyroidism, the period of low thyroid hormones is relatively short and transient. However, one may hypothesize that, especially in preterm infants, even a relatively short period of severe hypothyroidism could negatively impact brain development with potential lifelong consequences.

We speculate that prolonged enteral exposure to ICM may result in increased iodine uptake, although it is unknown if intestinal permeability, the duration of stasis or the amount and concentration of the ICM contrast plays a role in development of hypothyroidism. Our case illustrated that the contrast remained in the bowel until rectal irrigation, nineteen days after fistulogram. The higher the iodine exposure, the likelier it is that the Wolff-Chaikoff effect occurs and premature infants are more likely to be unable to escape the inhibitory Wolff-Chaikoff effect, resulting in prolonged thyroid dysfunction. Therefore, stasis of ICM may be one of the risk factors contributing to the development of contrast-induced hypothyroidism.

Following the reported recent case in our center, speculation arose regarding the severity, length and frequency of this complication in infants since thyroid function monitoring was not standard care for those receiving enteral ICM. The results of the literature review showed only two previous publications describing four infants suffering from contrast induced hypothyroidism. However, the potential complication of enteral ICM-induced hypothyroidism have been reported in additional publications that were not included in our systematic review due to incomplete data (9,25,26,27,28). It has been suggested in some of these publications that monitoring of thyroid function after enteral administration of ICM is warranted until an evidence based guideline is available, and this suggestion has been made by the PES and ACR as well (27,28). Although

overall evidence is limited, the available data suggests that contrast induced hypothyroidism might be a more frequent complication after the use of enteral ICM then previously realized. Consequently, a local protocol was implemented as standard care in our hospital, consisting of standard testing of thyroid function and abdominal X-rays to detect stasis of contrast in infants after enteral ICM administration.

Study Limitations

This case-report and systematic review aimed to provide insights into the clinical presentation of iodine-induced hypothyroidism in infants following enteral ICM administration. However, several limitations must be acknowledged. The finding of this case-report might be specific to the individual patient described and may not be applicable to a broader population or different clinical setting. In addition, the urinary iodine excretion was measured 26 days after enteral ICM administration. At that time, urinary iodine levels were not elevated. However, we believe that urinary iodine levels would have been high shortly after prolonged (19 days) enteral exposure to ICM. In retrospect, earlier evaluation of urinary iodine excretion could have confirmed systemic exposure to high levels of iodine. The primary limitation of the systematic review is that none of the included studies specifically focused on the occurrence of contrast-induced hypothyroidism in infants. Furthermore, publication bias could impact results, as unreported negative cases make determining the number of cases of contrast-induced hypothyroidism challenging. Nevertheless, this is the first systematic review reporting on the effect of enteral ICM on thyroid function in infants.

Conclusion

We present a case-report of contrast-induced hypothyroidism after prolonged stasis of administered enteral ICM in a premature infant. Additional studies on the severity, length and frequency of this complication are lacking, as our systematic review only identified two studies reporting on enteral ICM-induced hypothyroidism with a very small sample size. Therefore we are unable to report the true number of cases of contrast-induced hypothyroidism in infants who were exposed to enteral ICM. In line with the PES and ACR statements, we recommend monitoring of thyroid function after the use of enteral ICM in all infants until an evidence-based guideline is available.

Ethics

Ethics Committee Approval: The Medical Ethics Review Committee of Amsterdam University Medical Centers is registered with the US Office for Human Research

Protections (OHRP) as IRB00013752. The FWA number assigned to Amsterdam UMC is FWA00032965.

Informed Consent: Informed consent was obtained for publication from parents of the patient that is described in the case-report.

Footnotes

Authorship Contributions

Surgical and Medical Practices: Joep P. M. Derikx, L. W. Ernest van Heurn, Joost van Schuppen, Sandra E. Zoetelief, Wes Onland, Christiaan F. Mooij, Nitash Zwaveling-Soonawala, A. S. Paul van Trotsenburg, Concept: Adinda G. H. Pijpers, Joep P. M. Derikx, L. W. Ernest van Heurn, Joost van Schuppen, Wes Onland, Christiaan F. Mooij, Nitash Zwaveling-Soonawala, A. S. Paul van Trotsenburg, Design: Adinda G. H. Pijpers, Joep P. M. Derikx, Wes Onland, Christiaan F. Mooij, Data Collection or Processing: Adinda G. H. Pijpers, Laurens D. Eeftinck Schattenkerk, Ralph de Vries, Analysis or Interpretation: Adinda G. H. Pijpers, Joep P. M. Derikx, Laurens D. Eeftinck Schattenkerk, Christiaan F. Mooij, Literature Search: Adinda G. H. Pijpers, Laurens D. Eeftinck Schattenkerk, Ralph de Vries, Writing: Adinda G. H. Pijpers, Joep P. M. Derikx, Joost van Schuppen, Sandra E. Zoetelief, Wes Onland, Christiaan F. Mooij, Nitash Zwaveling-Soonawala, A. S. Paul van Trotsenburg.

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References

1. Macchia PE, Lapi P, Krude H, Pirro MT, Missero C, Chiovato L, Souabni A, Baserga M, Tassi V, Pinchera A, Fenzi G, Grüters A, Busslinger M, Di Lauro R. PAX8 mutations associated with congenital hypothyroidism caused by thyroid dysgenesis. *Nat Genet.* 1998;19:83-86.
2. van Trotsenburg P, Stoupa A, Léger J, Rohrer T, Peters C, Fugazzola L, Cassio A, Heinrichs C, Beauloye V, Pohlenz J, Rodien P, Coutant R, Szinnai G, Murray P, Bartés B, Luton D, Salerno M, de Sanctis L, Vigone M, Krude H, Persani L, Polak M. Congenital hypothyroidism: a 2020-2021 Consensus Guidelines update-an ENDO-European Reference Network Initiative Endorsed by the European Society for Pediatric Endocrinology and the European Society for Endocrinology. *Thyroid.* 2021;31:387-419.
3. Simoneau-Roy J, Marti S, Deal C, Huot C, Robaey P, Van Vliet G. Cognition and behavior at school entry in children with congenital hypothyroidism treated early with high-dose levothyroxine. *J Pediatr.* 2004;144:747-752.
4. Rath CP, Thomas M, Sullivan D, Kluckow M. Does the use of an iodine-containing contrast agent to visualise the PICC tip in preterm babies cause hypothyroidism? A randomised controlled trial. *Arch Dis Child Fetal Neonatal Ed.* 2019;104:212-214. Epub 2018 May 28
5. Dillman JR, Forbes-Amrhein MM, Wang CL, Asch D, Cavallo J, Ellis JH, Gilligan LA, Krishnan P, McDonald RJ, McDonald JS, Murphy BL, Mervak BM, Newhouse JH, Pahade JK, Sumkin A, Weinreb JC, Weinstein S, Davenport MS. ACR statement on use of iodinated contrast material for

- medical imaging in young children and need for thyroid monitoring. *J Am Coll Radiol.* 2022;19:849-853. Epub 2022 Jun 7
6. Barr ML, Chiu HK, Li N, Yeh MW, Rhee CM, Casillas J, Iskander PJ, Leung AM. Thyroid dysfunction in children exposed to iodinated contrast media. *J Clin Endocrinol Metab.* 2016;101:2366-2370. Epub 2016 Mar 28
 7. Belloni E, Tentoni S, Puci MV, Avogliero F, Della Latta D, Storti S, Alberti B, Bottoni A, Bortolotto C, Fiorina I, Montomoli C, Chiappino D. Effect of iodinated contrast medium on thyroid function: a study in children undergoing cardiac computed tomography. *Pediatr Radiol.* 2018;48:1417-1422. Epub 2018 May 31
 8. Aliefendioglu D, Sanli C, Cakmak M, Agar A, Albayrak M, Evliyaoğlu O. Wolff-Chaikoff effect in a newborn: is it an overlooked problem? *J Pediatr Surg.* 2006;41:1-3.
 9. Ahmet A, Lawson ML, Babyn P, Tricco AC. Hypothyroidism in neonates post-iodinated contrast media: a systematic review. *Acta Paediatr.* 2009;98:1568-1574. Epub 2009 Jul 3
 10. l'Allemand D, Grüters A, Beyer P, Weber B. Iodine in contrast agents and skin disinfectants is the major cause for hypothyroidism in premature infants during intensive care. *Horm Res.* 1987;28:42-49.
 11. Aitken J, Williams FL. A systematic review of thyroid dysfunction in preterm neonates exposed to topical iodine. *Arch Dis Child Fetal Neonatal Ed.* 2014;99:21-28. Epub 2013 Oct 8
 12. Callahan MJ, Iyer RS, Wassner AJ. Is thyroid monitoring warranted in infants and young children after intravascular administration of iodine-based contrast media? *AJR Am J Roentgenol.* 2023;220:144-145. Epub 2022 Jun 22
 13. Bramer WM, Giustini D, de Jonge GB, Holland L, Bekhuis T. De-duplication of database search results for systematic reviews in EndNote. *J Med Libr Assoc.* 2016;104:240-243.
 14. Ouzzani M, Hammady H, Fedorowicz Z, Elmagarmid A. Rayyan-a web and mobile app for systematic reviews. *Syst Rev.* 2016;5:210.
 15. Munn Z, Barker TH, Moola S, Tufanaru C, Stern C, McArthur A, Stephenson M, Aromataris E. Methodological quality of case series studies: an introduction to the JBI critical appraisal tool. *JBIC Evid Synth.* 2020;18:2127-2133.
 16. Fenton TR, Kim JH. A systematic review and meta-analysis to revise the Fenton growth chart for preterm infants. *BMC Pediatr.* 2013;13:59.
 17. Ares SS, de Pipaón Marcos MS, Ruiz-Díaz AI, de Escobar M, Quero JJ. Hypothyroidism and high plasma and urine iodine levels related to the use of gastrografin. *Curr Pediatr Rev.* 2008;4:194-197.
 18. Lombard F, Dalla-Vale F, Veyrac C, Plan O, Cambonie G, Picaud JC. Severe hypothyroidism after contrast enema in premature infants. *Eur J Pediatr.* 2009;168:499-500. Epub 2008 Jul 11
 19. Markou K, Georgopoulos N, Kyriazopoulou V, Vagenakis AG. Iodine-Induced hypothyroidism. *Thyroid.* 2001;11:501-510.
 20. Fisher DA, Klein AH. Thyroid development and disorders of thyroid function in the newborn. *N Engl J Med.* 1981;304:702-712.
 21. Theodoropoulos T, Braverman LE, Vagenakis AG. Iodide-induced hypothyroidism: a potential hazard during perinatal life. *Science.* 1979;205:502-503.
 22. Gilligan LA, Dillman JR, Su W, Zhang B, Chuang J, Trout AT. Primary thyroid dysfunction after single intravenous iodinated contrast exposure in young children: a propensity score matched analysis. *Pediatr Radiol.* 2021;51:640-648. Epub 2020 Nov 17
 23. Grosse SD, Van Vliet G. Prevention of intellectual disability through screening for congenital hypothyroidism: how much and at what level? *Arch Dis Child.* 2011;96:374-379. Epub 2011 Jan 17
 24. Cherella CE, Wassner AJ. Congenital hypothyroidism: insights into pathogenesis and treatment. *Int J Pediatr Endocrinol.* 2017;2017:11. Epub 2017 Oct 2
 25. Leung AM, Braverman LE. Iodine-induced thyroid dysfunction. *Curr Opin Endocrinol Diabetes Obes.* 2012;19:414-419.
 26. Heo YJ, Lee YA, Lee B, Lee YJ, Lim YH, Chung HR, Shin SH, Shin CH, Yang SW. How can the occurrence of delayed elevation of thyroid stimulating hormone in preterm infants born between 35 and 36 weeks gestation be predicted? *PLoS One.* 2019;14:e0220240.
 27. Putnins R, Ahmet A, Rigby C, Miller E. Risk of hypothyroidism after administration of iodinated contrast material in neonates: are you aware? *Can Assoc Radiol J.* 2021;72:192-193. Epub 2020 May 1
 28. Ruiz-Díaz A, Marcos MSDP, Escobar GMD, Jimenez JQ. 315 hypothyroidism and high plasma and urine iodine levels related to the use of gastrografin. *Pediatr Res.* 2005;58:408.

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