Role of colonic distention at CT with water enema and CT colonography in inducing incidental physiologic sliding hiatal hernia

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Aims and objectives

Although a barium-contrast radiography originally constituted the first development in diagnosing hiatal hernia (HH) and gastroesophageal reflux, nowadays conventional radiology is no more an accurate investigation for their assessment. Paradoxically, we noticed a tendency to a negative contribution to the management of these conditions. In fact, we observed in clinical practice a worrisome rate of HH reported as incidental extra-colonic finding during CT with water enema (CT-WE) and CT colonography (CTC). This suspicious has been recently confirmed by the study of Pickhardt et al., which demonstrated a trend of overestimation of the hiatus hernia dimensions and a not entirely negligible number of misdiagnosed cases [1]. A deductive explanation is that colon distention induced by water or gas perfusion/delivery increases intra-abdominal pressure, thus favouring a transitory displacement of the cardias and partially the stomach through the diaphragm into the thorax, defined as "sliding" or "type I" HH [2]. As a fact, it has been already demonstrated that abdominal obesity by increasing intra-abdominal pressure promotes reflux and the development of hiatus hernia [3].

Hiatal hernia is a well known factor impacting on most mechanisms underlying gastroesophageal reflux (low sphincter pressure, transient lower oesophageal sphincter relaxation, oesophageal clearance and acid pocket position), explaining its association with more severe disease and mucosal damage [4-6]. These latter in turn, are related with the risk of complications such as erosive esophagitis, Barrett’s esophagus and ultimately, oesophageal adenocarcinoma [7, 8]. Therefore, although HH itself is a not life-threatening condition its diagnosis may induce on patients, often not correctly instructed, worries and psychological distress that notably impact on quality of life. Moreover, several studies have demonstrated a bi-directionally cause-effect interrelationship between upper gastrointestinal symptoms and psychological distress [9]. As a consequence of that, an erroneous diagnosis of a fictional disease may potentially lead to a true functional disorder. This latter, above all GERD and dyspepsia, deeply bear upon the socio-sanitary costs by increasing utilization of healthcare resources (i.e. frequent visits to physicians, long-term medications use, redundant invasive expensive investigations) and reducing work productivity (i.e. absenteeism and presenteeism) [10, 11]. These costs are even more inadequate if led by a initial misdiagnosis.

The search for the presence of HH should then be limited on subjects with typical manifestations - such as epigastric pain, belching, heartburn and regurgitation, especially when refractory to treatment or when alarm signs are present. Whenever possible, the diagnosis and estimation of the hernia, should be assessed by reference standard methods, such as esophageal manometry or even high-resolution manometry. This investigation provides further information, particularly for type I HH, and is mandatory in case surgical treatment is considered [12-14]. Therefore, it is our opinion that an
erroneous reporting of HH may trigger a consecutive diagnostic process that is not only unnecessary, inducing a unmotivated anxiety in the patient, but also expensive and time-consuming for both the patient and the healthcare system [15]. As a consequence, the purposes of our study were to determine whether colonic distention at CT-WE and CTC can induce a small incidental physiologic sliding hiatal hernias and to detect if hiatal hernias size modifications could be considered significant for both water and gas distention techniques.
Methods and materials

Inclusion of patients

This was a retrospective study, approved by our institutional review board. The primary study groups were derived from 400 consecutive patients, 200 undergoing CT-WE and 200 undergoing CTC at our unit of radiology starting from January 1, 2013. The mean age of the CT-WE cohort (118 women, 82 men) was 66.5 ± 14.2 (SD) years, while the mean age of the CTC group (127 women, 73 men) was 65.7 ± 12.4 (SD) years. Among the patients with a HH at CT-WE and CTC, PACS record review identified 59 subjects (31 in the CT-WE group and 28 in the CTC group) who also underwent a routine abdominal CT evaluation on a different time and this groups of patients served as internal control subjects; a total of 44 abdominal CT examinations were performed before CT-WE (21) or CTC (23) and 15 CT examinations were performed after CT-WE (10) or CTC (5). A separate group of 200 consecutive patients who underwent abdominal CT evaluation at our institution in the same period was used as external control: the mean age of this cohort was 67.4 ± 13.2 (SD) years and included 111 women and 89 men. All the studies were performed for a variety of diagnostic indications (e.g. suspect IBD, evaluation of colon cancer, evaluation of diverticulitis); emergency cases and ER patients, unable to undergo a proper intestinal preparation before the CT exams, were not included.

CT-WE and CTC techniques

Bowel cleansing consisted in a low-fiber diet for 3 days before the CT-WE or CTC examination. The day before the examination, after a low-fiber meal at noon, each patient was instructed to drink continuously four doses of a granular powder (Isocolan; Bracco, Milan, Italy; each dose contains 34.8 g polyethylene glycol 4000, 1.42 g anhydrous sodium sulfate, 0.42 g sodium bicarbonate, 0.36 g sodium chloride, and 0.18 g potassium chloride) dissolved in 2 liters of water.

CT-WE technique was performed as previously described by Paparo et al. [16]. All examinations were performed with a 64-slice multidetector CT scanner (Light Speed VCT, GE Medical Systems, Milwaukee, WI) with the patient in supine position and end inspiration apnea. Contrast-enhanced CT was performed using the following scanning parameters: 120 kV, 300mAs (with automatic mA modulation in the z axis), 0.7 sec rotation time, detector collimation 40mm, section thickness 5 mm, table speed 39.37mm per rotation. Bowel wall enhancement was produced by intravenous injection of iodinated contrast medium with an iodine concentration of 350 mg/mL (Iobitridol, Xenetix, Guerbet). The flow rate was set at 3.2-3 mL/s with an automatic injector and acquisition was started in the portal phase, 45 s after the arterial peak in the upper abdominal aorta using a bolus-tracking software. Immediately before CT acquisition, bowel hypotonia was obtained by i.v. injection of 2 mL hyoscine-N-butylbromide 20 mg/mL (Buscopan, Boehringer Ingelheim), in order to reduce abdominal discomfort of patients and to avoid
motion artifacts during the acquisition. The estimated mean effective dose for CT-WE protocol was 11 mSv.

CTC technique was performed for the purpose of colorectal evaluation [17], as described in previous works [18]. The pre-imaging protocol for colonography included bowel preparation (as described for CT-WE) and, the day before examination, fecal tagging with oral iodinated contrast media. Gas distention of the colon was obtained with room air gently pumped using a hand-held squeeze bulb in the rectum through a short cannula [18]. CTC was performed during end inspiration apnea. Supine and prone acquisitions were obtained with the same 64-slice multidetector CT scanner with the following protocol: 120 kV, 80 mA, 0.7 sec rotation time, detector collimation 40mm, section thickness 5 mm, and table speed 39,37mm per rotation. No iv iodated contrast medium was used in our CTC protocol. The CTC protocol has an average effective dose of 6 mSv. Only the supine series was used in this study to evaluate for the presence of HH.

For the internal and external abdominal CT control groups, standard diagnostic supine imaging used routine technique without colonic distention performed at end inspiration apnea. These CT exams were performed for various indications and comprehended both unenhanced and contrast-enhanced CT examinations, with acquisitions tailored on the basis of the clinical query.

*Hiatal hernia evaluation*

Retrospective assessment of the CT study groups for the presence or absence of a sliding hiatal hernia was performed by two board-certified abdominal radiologists, both with more than 5 years of experience in abdominal CT interpretation. The findings used to identify a HH at CT included: gastric rugal folds; soft-tissue fullness separate from the tubular esophagus; lobulated or irregular enteral contour above the esophageal hiatus; a combination of these signs. If a HH was present, the size was subjectively graded as small, moderate, or large by the reader. After the assessment of the single groups, the internal control groups of CT-WE and CTC groups were directly compared with the corresponding CT-WE or CTC study to evaluate for a change in hernia size. If more than one routine CT study was available for the internal control groups, the closest examination before/after CT-WE or CTC was used.

*Statistical analysis*

Data were analyzed with SPSS software (IBM, Statistical Package for Social Science). Values are considered significantly different when p<0.05. Difference between groups were assessed with Fisher test and ANOVA for difference in mean values, Mann-Whitney test for data not normally distributed, difference in counts and frequency. A size-specific correction factor was empirically derived and was applied to the baseline hernia rate using the results from the internal control group, in order to account for the effect of colonic distention at CTC. Specifically, the percentages of hernias that resolved or decreased in
size in patients with an internal control examination were used to estimate the expected underlying baseline hernia rates at CT-WE and CTC: these values were then individually compared with the external control group.
Results

No statistical significant differences were found among the groups enrolled in terms of demographic and epidemiological characteristics (Table 1).

A sliding hiatal hernia was present in 51% (102/200) of the patients belonging to the CT-WE cohort and in 48.5% (97/200) of the patients in the CTC group. In CT-WE patients, hernia size was reported as small in 82.4% (84/102) of patients, moderate in 12.7% (13/102), and large in 4.9% (5/102). In CTC patients, hernia size was categorized as small in 79.4% (77/97) of patients, moderate in 14.4% (14/97), and large in 6.2% (6/97).

Internal control abdominal CT of the 31 subjects with a hernia at CT-WE showed absence (i.e. resolution) of the hernia in 58.1% (18/31) of patients (Figure 1), including 76.5% (13/17) and 45.5% (5/11) of small and moderate hernias, respectively. None of the 3 large hernias among the internal control patients at CT-WE was absent at comparison abdominal CT, and the routine CT compared with CT-WE showed a reduction in hernia dimension in 7 additional patients. Using these findings to evaluate the CT-WE cohort we assumed that 23.5% of small hernias, 54.5% of moderate hernias and 100% of large hernias would have been present without colonic distention associated to CT-WE.

In the 28 patients with a HH at CTC the comparison abdominal CT, used as internal control, showed absence (i.e. resolution) of the hernia in 57.1% (16/28) patients (Figure 2), including 68.8% (11/16) and 50% (5/10) of small and moderate hernias, respectively. None of the 2 large hernias among the internal control subjects at CTC was absent at comparison abdominal CT and the routine CT compared with CTC showed a hernia down-sizing in additional 4 patients: using these findings to evaluate the CTC cohort, we considered that 31.2% of small hernias, 50% of moderate hernias and 100% of large hernias would have been present without colonic distention associated with CTC.

The prevalence of sliding hiatal hernias in the external control group was 22% (44/200), significantly lower than the CT-WE and CTC cohorts' prevalence of 51% (p < 0.0001) and 48.5% (p < 0.0001), respectively. These hernias were small-sized in 77.3% (34/44), moderate-sized in 13.6% (6/44) and large-sized in 9.1% (4/44), as showed in Table 1. After applying the correction factors for the CT-WE and the CTC groups, the estimated residual prevalences (16% and 18.5%, respectively) were much closer to that of the external control patients (p = 0.160 for CT-WE and p = 0.455 for CTC), as showed in Table 2. There was no statistical significant difference in terms of dimension of the HH between gas-induced and water-induced distention.
Images for this section:

**Fig. 1:** Small hiatal hernia (arrow in A) seen at CT with water enema (CT-WE) in a 76-years-old man, undergoing the investigation as follow-up of Crohn's disease. The corresponding image from a routine CT examination performed 8 months after CT-WE (B) shows no evidence of hiatal hernia.

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**Fig. 2:** Scout (A) and supine axial (B) images of a 66-years-old woman, undergoing screening CT colonography (CTC) evaluation, show the presence of a small hiatal hernia; note the mass effect on stomach determined by the gaseous distention of the splenic flexure (arrow in A). The corresponding image from a routine CT examination performed 1 year before CTC (C) shows no evidence of hiatal hernia.

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Table 1: Clinical and epidemiologic characteristics of the population; prevalence and size assessment of sliding hiatal hernias at CT with water enema (CT-WE), CT colonography (CTC) and abdominal CT (used as external control). * The correction factor is based on the estimated 76.5% and 45.5% reduction in small and moderate-sized hiatal hernias, respectively, without colonic distention with CT-WE. ** The correction factor is based on the estimated 68.8% and 50% reduction in small and moderate-sized hiatal hernias, respectively, without colonic distention with CTC.

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Table 2: P values for comparison between CT-WE cohort and external CT control group and between CTC cohort and external CT control group.

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Conclusion

The main source of inspiration for this work was the study by Pickhardt et al. [1] affirming that small transient sliding hiatal hernias are commonly induced by colonic distention at CTC and should not be reported: their results pushed us to verify if such circumstance was relevant for CT-WE as well, in order to start correcting a trend of over-reporting and the resulting inappropriate management of these patients.

The evaluation of complex and panoramic exams such as abdominal CT with water enema or CT colonography represents a constant challenge for gastrointestinal radiologists in their daily practice: the number of different findings to consider when assessing this kind of examinations is particularly high and the clinical informations about the recent medical history of the patient play a central role. Since the amount of unnecessary workup for the wide variety of benign extracolonic findings is particularly relevant for CTC [19,20] radiologists have to correctly assess as well extracolonic findings of CT-WE studies. It is therefore important to underline, if possible, when additional evaluation may not be required.

With this precondition, incidental findings should be considered according to the clinical background, and the presence of HH is a classic circumstance in which lack of specific symptoms of gastroesophageal reflux disease may suggest scanty clinical relevance [21]. There are many concerns at this regard. An inappropriate diagnosis may lead a considerable proportion of patients to consult their own physician which in turn will be tempted to prescribe antacids and antisecretory drugs. Part of these subjects eventually refer to the gastroenterologist and undergo specialistic investigations. These latter, usually consist in barium swallow radiology or esophagogastroduodenoscopy, which are invasive, do not affect the management of the patient and do not provide information about the esophageal function and gastroesophageal barrier competency in controlling gastroesophageal refluxes. Moreover, although HH itself is not a life-threatening condition its diagnosis may induce on patients, often not correctly instructed, worries and psychological distress. As a consequence of that, a fictional disease may potentially lead to a true functional disorder that notably impacts on quality of life. In fact a bi-directionally cause-effect interrelationship exists between gastrointestinal symptoms and psychological distress. Specifically for the upper digestive tract, a very recent review reported as a significant proportion of patients - up to 61% - reporting heartburn without any proved pathologies, improve under antidepressant therapy. A similar improvement is recorded also for chestpain and esophageal pain thresholds [9]. Beside the costs that burden patients and the healthcare system, all that has indirect costs for the Society. Several meta-analysis showed a negative impact on work productivity, defined as absence from work (absenteeism) as well as reduced effectiveness while working (presenteeism) [10, 11, 22]. Although these processes are commonly experienced during our clinical routine, this study did not asses the effect of the diagnosis of HH on patients’ quality of life, as it was not part of the aims. Therefore, the impact of the misdiagnosis on
sociosanitary costs should be considered a mere speculation. Another concern is who and how should be investigated for HH. It has wide prevalence in the population, about 30% even among healthy subjects [23]. No screening and invasive investigations are required in absence of symptoms or alarm signs (i.e. anemia, dysphagia, arrhythmia). The most frequent finding is the Type I HH (axial) whose major significance is the association with GERD and it is also more difficult to precisely estimate. When bigger than 2 cm, it can be easily diagnosed by conventional Barium swallow, endoscopy and traditional manometry. However, the gastroesophageal "barrier" is a dynamic concept where multiple structures vary their anatomic relationship continuously with breathing, eating, body movements and even spontaneously. Moreover, it can be transitory induced by gastric and esophageal distention during X-ray and upper endoscopy. Although more sophisticated, traditional manometry presents also some limitations due to the low number of pressure sensors and the inter-individual variability, thus potentially jeopardize the reliability of a landmark such as the pressure inversion point. High-resolution manometry (HRM) seems to overcome these shortcomings, allowing real time detection of lesser degrees of axial separation between the lower esophageal sphincter and crural diaphragm, distinguishing swallow and distention related artifacts [2,24,25]. Nowadays, HRM is considered the "gold standard" for HH assessment. In addition, the employment of physiopathologic methodologies allow the recognition of esophageal dysmotilities, which is of capital importance in the eventuality of fundoplicatio to avoid a complete therapeutic failure and postoperative complications [14].

Our results confirm the relationship between CTC technique and small sliding hernias showed by Pickhardt et al. [1], as well as the substantial matching between the external control group and the residual prevalence of hiatal hernias after excluding the estimated subset of small sliding HH most likely due to gaseous colonic distention. It is interesting to note that we obtained similar results considering a group of patients undergoing CT-WE and comparing them with the external control group.

Considering that the increased intra-abdominal pressure from colonic distention induces migration of part of the stomach through the diaphragmatic hiatus [26], it is likely that most of small sliding hiatal hernias found at CT-WE and CTC will disappear or reduce in size at routine CT exams used as internal control.

In addition, the lack of a statistically significant difference between CT-WE and CTC results suggests a merely mechanical pathogenesis of HH, where the water or air-related colonic distention unsettles the intra-abdominal pressure balance, thus promoting the onset of HH [27]: moreover in some CTC patients, the direct compression of distended left colonic flexure on the stomach may contribute to the causative mechanism.

On the contrary, we noticed that most of moderate and especially of large-sized hernias will not disappear in routine CT evaluation (Figure 3), thus suggesting that small hernias are the main entities to consider as part of the distention-induced pathogenetic mechanism.
However, our study has several limitations: first of all, the diagnosis of HH at CT is limited by a certain grade of subjectivity, especially at CTC, being the contrast enhanced CT-WE exams more sensitive in identifying the peculiar findings of HH; the prevalence of symptoms of reflux disease in our group of patients was unknown; we evaluated only supine scans in CTC cohort; we use an end-inspiration phase in all our CT acquisition protocols (same phase for CTC, CT-WE and routine abdominal CT), possibly leading to an increase of HH prevalence due to augmented intra-abdominal pressure.
Fig. 3: CT-WE axial image of a 85-years-old woman (A) showing the presence of a moderate-sized hiatal hernia. The finding was confirmed at the routine CT performed 16 months before (B) used as internal control, that shows no modifications of the hernia.

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References


