The Utility of Functional Luminal Imaging Probes Measurements to Diagnose Dysmotility and Their Relationship to Impaired Bolus Clearance

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ABSTRACT

Background: Functional luminal imaging probes (FLIP) have been used by multiple centers to assess esophagogastric junction (EGJ) function in patients at risk for esophageal obstruction but its role in diagnosing peristaltic disorders is less well studied. In particular, there are no studies comparing the sensitivity of FLIP to diagnose motility abnormalities and impaired bolus transit by high-resolution esophageal manometry with impedance.

Methods: We prospectively recruited 42 patients undergoing high-resolution esophageal manometry with impedance (HRIM) who also underwent FLIP between 2018 and 2020. HRIM parameters were analyzed using Swallow Gateway software to determine peristaltic and lower esophageal sphincter pressure measurements as well as bolus flow parameters. FLIP tracings were analyzed for the presence of repetitive antegrade contractions (RACs), EGJ distensibility, and associated parameters.

Results: Forty-two patients were included (11 controls, 7 achalasia, 16 fundoplication, 8 dysmotility). The mean age of patients was 10.1 ± 0.9 years. There were significant differences in bolus flow parameters across diagnosis with longer bolus presence (BPT) in control patients compared with fundoplication and dysmotility patients. There was a significant correlation between EGJ diameter, EGJ distensibility and bolus flow time (BFT) for solid foods ($r^2 > 0.518$, $P < 0.02$). The presence of RACs and EGJ relaxation during RACs was associated with a greater BFT and BPT across textures ($P < 0.05$). Forty-two percentage of patients with absent RACs, however, had clear peristalsis by HRIM.

Conclusions: The presence of RACs and EGJ relaxation by FLIP correlate with improved bolus flow. Patients with an absence of RACs need HRIM to confirm any diagnoses of dysmotility.

Key Words: dysmotility, functional luminal imaging probe, high-resolution esophageal manometry, impedance, panometry

An infographic is available for this article at: ***http://links.lww.com/MPG/C674***.

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What Is Known

- Functional luminal imaging probe has been used to assess esophagogastric junction distensibility and recently to assess secondary peristalsis in adults.
- High-resolution manometry with impedance can pair pressure parameters with bolus flow.
- There are no studies that have compared functional luminal imaging probe panometry results with bolus flow.

What Is New

- The presence of repetitive antegrade contractions and higher esophagogastric junction distensibility by functional luminal imaging probe correlates with improved bolus flow.
- While functional luminal imaging probe peristaltic and esophagogastric junction parameters are correlated with high-resolution impedance manometry parameters, persistent symptoms merit testing by both modalities.
- Bolus flow times and bolus presence times are significantly lower in fundoplication and dysmotility patients compared to controls

The functional luminal imaging probe (FLIP) has been used in adults and children to assess lower esophageal distensibility as a new method to assess esophagogastric junction (EGJ) function. With the addition of panometry, however, FLIP has become an even more powerful tool to assess not only EGJ function but also peristaltic integrity. This tool is particularly powerful in pediatrics as patient cooperation is not required; while under anesthesia at the time of

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endoscopy, the FLIP balloon is inflated in the esophagus to measure compliance, trigger EGJ relaxation and secondary peristaltic waves, which reflect neuromuscular integrity of the esophagus.

Although there are pediatric studies that have correlated FLIP-measured EGJ function with lower esophageal sphincter relaxation using high-resolution esophageal manometry, HRM, (ie integrated relaxation pressure, IRP), there are no pediatric studies of FLIP to diagnose peristaltic disorders or to correlate FLIP-defined peristaltic events with esophageal function and emptying using novel bolus clearance metrics, obtained during high-resolution impedance manometry (HRIM) (1–3). As FLIP technology is being increasingly used more, even in centers where no esophageal manometry is available, these additional studies are critical to understand the correlation between peristaltic activity using panometry with traditional HRIM values. In addition, the relative importance of secondary peristalsis by FLIP compared with primary peristalsis in the assessment of dysphagia needs to be clarified in order to avoid over-diagnosing motility disorders that may have no practical consequence and cannot be confirmed by HRM, and to understand the role of secondary peristaltic abnormalities on esophageal symptoms.

To clarify the relationship between motility abnormalities diagnosed by FLIP or HRM, Carlson et al recently compared these tests to the results of timed barium esophagrams, finding that, whenever tests are discordant, FLIP parameters correlate better with bolus stasis than HRM. There are, however, other measures of bolus stasis than esophagrams including bolus flow by impedance that is measured at the time of HRIM. Omari et al have proposed several novel measures of bolus stasis including bolus flow time, bolus presence time, and the pressure-flow index (4,5). Bolus presence time is the duration of bolus presence within the EGJ with higher numbers representing better flow bolus transport to EGJ. Bolus flow time is strongly correlated with BPT and represents flow through the EGJ when taking into account the diaphragmatic influence. In addition to BFT and BPT, the pressure flow index has been proposed as a way to capture the interactions between peristalsis and EGJ obstruction with higher number signifying more abnormal esophageal dysfunction. No studies have looked at the relationship between these bolus parameters and findings on FLIP but understanding this relationship is critical in order to clarify if the FLIP findings in children are clinically meaningful.

The goal of this study was to determine the peristaltic patterns seen in children during FLIP and the correlation between FLIP-defined peristaltic and EGJ parameters with bolus flow parameters measured during HRM with impedance (HRIM).

METHODS

We prospectively recruited patients who underwent HRIM before they were scheduled for an upper endoscopy during which FLIP was performed between 2018 and 2020. Patients were categorized into the following 4 groups by diagnosis based on HRIM testing or, whenever present, based on history of fundoplication: controls (patients with normal peristaltic amplitude and LES relaxation by HRIM); fundoplication; achalasia; and abnormal peristalsis as defined by Chicago 3 classification with normal EGJ function. The protocol was approved by the Boston Children's Hospital IRB, and informed consent was obtained from each family, and assent from those children older than 8 years.

Functional Luminal Imaging Probe

All FLIP studies were performed under general anesthesia with propofol. The FLIP was placed transorally and positioned within the esophagus with 1 to 3 impedance sensors beyond the EGJ. For children <8 years old, the 80 mm balloon was used. For children >8 years old, the 160 mm balloon was used. Each patient had a FLIP curve with stepwise balloon distensions performed with inflation size dependent on the patient's age, size, and esophageal response (ie, observation of repetitive antegrade contractions or RACs); for younger children, maximum inflation was 30 ml and for older children, the maximum inflation was 60 ml. Each balloon inflation size was maintained for a minimum of 30 seconds before the balloon was inflated further. During each inflation, balloon pressures were monitored to ensure that there were no pressures >50 mmHg[2]. FLIP recordings were reviewed using the FLIP analysis program (Minneapolis, MN) to determine EGJ function: maximum distensibility, maximum diameter, and maximum pressure at each balloon size were measured. We then reviewed each inflation curve for the presence or absence of RACs, and whenever present, the rate of RACs (the number of RACs per screen, which represents 40 seconds). Breaks in the RACs were defined as lack of diameter occlusion for 2 or more consecutive sensors. GEJ relaxation during RACs was judged at maximum balloon inflation as: absent when there was no change in the GEJ diameter over baseline throughout the duration of secondary peristalsis; partial when there was any increase in diameter associated with a RAC; or complete when EGJ diameter was equivalent to the distal esophagus (6).

Peristalsis was assessed based on the following variables: RAC presence: were repetitive antegrade contractions present or absent; RAC onset: the balloon at which RACs were triggered; RAC rate: the number of peristaltic waves per 40 second window; RAC amplitude: the minimum occlusive diameter during RACs; RAC breaks: the presence or absence of peristaltic breaks (Fig. 1); and presence of EGJ relaxation associated with RACs (7,8). FLIP 2.0 software was used for analysis.

High-resolution Impedance Manometry

HRIM was performed using 2 catheters depending on age. For children older than 10 years old, a 12 french catheter HRIM catheter (36 pressure sensors, 12 Impedance sensors) was used (Medtronic, Minneapolis, MN) and in children <10 years old, a 6F HRIM catheter (25 pressure sensors, 12 impedance sensors) was used (Laborie, Williston, VT). A standard esophageal manometry (using 10 saline, 10 viscous, and 10 cookie swallows) was performed in the semi-upright position as previously described (9). Tracings were reviewed to assess for peristaltic and EGJ parameters (10). In addition to standard esophageal parameters, each swallow was individually analyzed in a blind fashion by a motility physician (R.R.) using Swallow Gateway (Flinders, Australia) software to determine, in addition to standard parameters (IRP, distal contractile integral [DCI], break size), the following parameters of bolus flow: pressure flow index (PFI); bolus presence time (BPT); and bolus flow time (BFT) (5).

Statistics

Values are expressed as mean ± SD. Baseline characteristics, as well as FLIP and HRIM parameters were compared using parametric (*t* test for 2-sample comparisons or 1-way ANOVA for more than 2 groups) or nonparametric testing (Mann-Whitney for 2-sample comparison, Kruskal-Wallis 1-way ANOVA for more than 2 groups) as appropriate. Proportions were compared using chi-square or Fischer exact test as appropriate. SPSS (version 24) was used for the analysis.

RESULTS

Forty-two patients had both FLIP and HRIM performed. The mean age of patients was 10.9 ± 6.1 years. The M : F ratio was

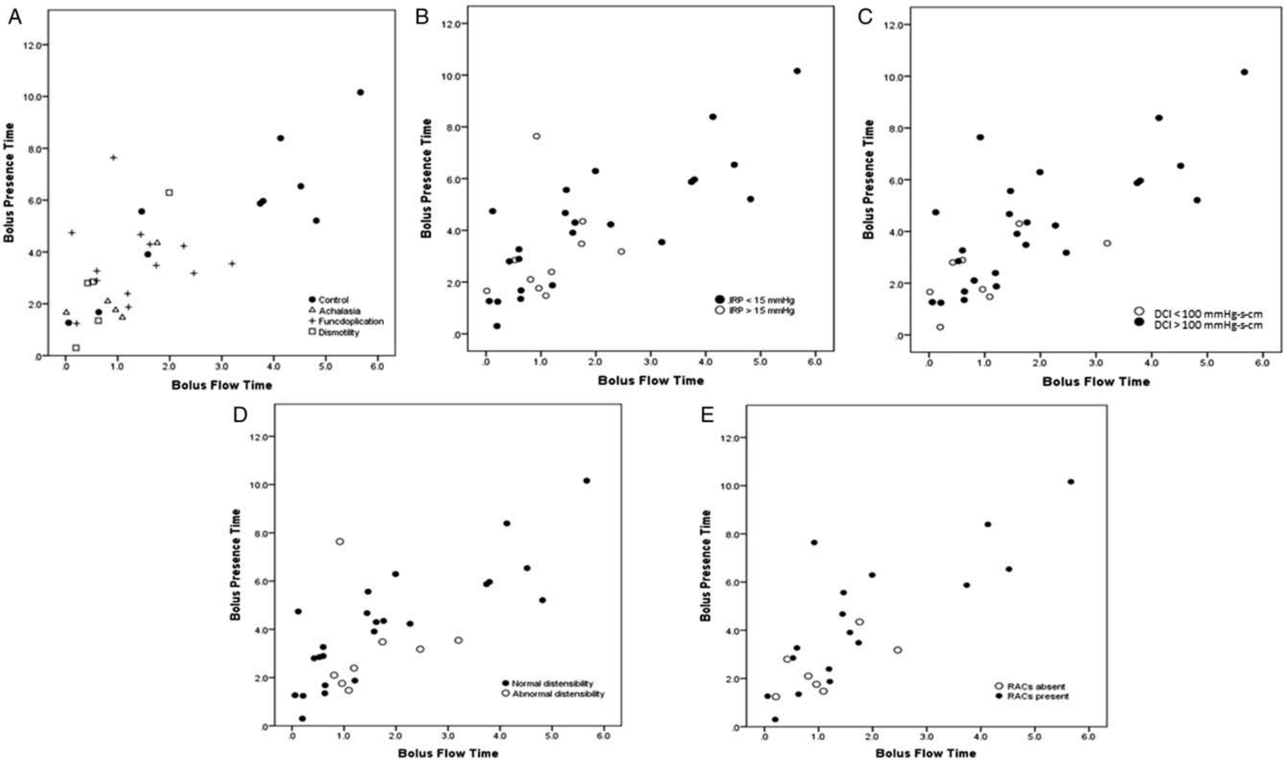

FIGURE 1. Relationship between bolus flow time (seconds) and bolus presence time (seconds) by diagnosis (A), integrated relaxation pressure (B), DCI (C), distensibility (D), and repetitive antegrade contractions (E). DCI = distal contractile integral.

24 : 18. Eleven control patients, 7 achalasia patients, 16 fundoplication patients, and 8 dysmotility patients were included. HRIM and FLIP parameters by group are shown in Table 1. Figure 1A shows the relationship between diagnosis and flow parameters.

High-resolution Impedance Manometry Peristaltic and Esophagogastric Junction Parameters

Key HRIM parameters are shown in Table 1; there were significant differences in bolus clearance and LES function when comparing between groups.

Functional Luminal Imaging Probe Peristaltic Parameters

Key FLIP parameters by diagnosis are shown in Table 1; there were significant differences when comparing EGJ distensibility and peristaltic characteristics. In patients with RACs, the median RAC frequency was 5 (range: 3–7 RAC per 40 seconds). The median balloon size where RACs were first seen was 20 mL (range: 15–50). The median occlusive diameter in the sensor closest to the lower esophageal sphincter was 7.4 mm (range: 5.8–17.3). The median pressure at the time of RAC start was 19.3 mmHg (range 4.3–27.4).

Correlation Between High-resolution Impedance Manometry and Functional Luminal Imaging Probe

The relationship between flow parameters and the presence of EGJ physiology (defined by IRP and by distensibility) is shown in Figure 1B and D. The relationship between peristaltic parameters (DCI and RACs) is shown in Figure 1C and E. The correlation between FLIP-defined EGJ parameters and bolus flow parameters is shown in Table 1, Supplemental Digital Content, *http://links.lww.com/MPG/C671*. As can be noted, greater EGJ diameter and distensibility as well as a low IRP are correlated with more effective bolus flow by HRIM. Similarly intact peristalsis (with intact RACs or DCI >450 mmHg s cm) are associated with more effective bolus flow.

We then compared bolus flow parameters in patients with absent versus partial EGJ relaxation during RACs (Table 2); even partial EGJ relaxation was associated with more effective bolus flow. We also found a significant difference in bolus flow parameters by diagnosis across swallowed textures (Table 2, Supplemental Digital Content, *http://links.lww.com/MPG/C672*).

Panometry-measured peristaltic parameters and bolus flow

The relationship between HRIM pressure parameters and the presence or absence of RACs is shown in Table 3 (with achalasia patients excluded as peristalsis is absent by definition). The presence of RACs was significantly associated with effective bolus clearance. There is a significant relationship between absent peristalsis (DCI < 100 mmHg) and absence of RACs ($P = 0.02$), although of the 7 patients with no RACs, 3 patients (42%) had DCI values >450. Of the patients with RACs, 1 patient had a DCI <100 and 7 patients had a DCI 100 to 450 suggesting an imperfect relationship between primary and secondary peristalsis.

We then divided the patients into those with BPT <4.6 or > 4.6 seconds or BFT <3.8 or >3.8 seconds, the mean values reported in a small pediatric case series (5). No patients with absent RACs or low DCI had a normal BFT or BPT. No patients with an

TABLE 1. Patient characteristics including motility and functional luminal imaging probe parameters by diagnosis

	Control	Achalasia	Dysmotility	Fundoplication	P value
N	11	7	8	16	
Age, years	14.0 ± 4.8	13.9 ± 4.2	9.5 ± 6.0	6.0 ± 52	0.001
HRIM					
Distal contractile interval, mmHg seconds cm	736.0 ± 160.3	236.4 ± 124.6	294.6 ± 212.1	448.9 ± 137.6	0.2
IRP, mmHg	6.0 ± 1.6	30.4 ± 6.1	12.4 ± 2.8	10.6 ± 1.6	0.0001
Mean bolus presence Time, seconds	5.4 ± 0.9	2.3 ± 0.5	2.7 ± 1.0	3.6 ± 0.4	0.03
Mean bolus flow time, seconds	3.0 ± 0.6	0.8 ± 0.3	0.7 ± 0.3	1.3 ± 0.2	0.002
Mean pressure flow index	13.6 ± 2.8	N/A	64.6 ± 55.5	57.5 ± 16.2	0.09
FLIP					
LES distensibility mm^2/mmHg	6.4 ± 0.7	2.5 ± 0.7	6.4 ± 0.7	3.1 ± 0.2	0.0001
RAC present (% of patients)	100%	0%	62.5%	75%	0.008
Occlusive diameter immediately above LES, mm	9.1 ± 1.1	N/A	10.9 ± 0.3	6.4 ± 0.3	0.07
Median balloon inflation to initiate RACs, cm^3, range	30 cc (20–50cc)	N/A	35 cc (25–40cc)	20 cc (15–20)	0.01
Mean pressure to initiate RAC, mmHg	16.1 ± 79	N/A	21.5 ± 5.0	18.3 ± 6.7	0.5

FLIP = functional luminal imaging probes; HRIM = high-resolution impedance manometry; IRP = integrated relaxation pressure; RAC = repetitive antegrade contractions.

abnormal EGJ distensibility or abnormal IRP had a normal BFT. We then compared bolus flow parameters in patients with lower RAC frequencies (<4.5 RAC per 40 seconds); bolus presence time was lower in patients with lower RAC frequencies (liquid: 3.2 ± 1.5, viscous: 3.5 ± 1.4, solid: 3.6 ± 1.7 seconds) compared with higher frequencies (liquid: 5.2 ± 3.1, viscous: 6.0 ± 1.0, solid: 5.8 ± 2.0 seconds, $P < 0.02$) with no difference in bolus flow time or pressure flow indices ($P > 0.05$). Figure 1c shows the relationship between flow parameters and the presence of RACs.

Relationship Between Esophagogastric Junction and Peristaltic Abnormalities and Bolus Flow

We divided patients by physiologic parameters (normal/abnormal IRP and/or DCI, normal/abnormal distensibility and/or RAC) and the resultant bolus flow parameters. These are shown in Figure 2A–D, Supplemental Digital Content, *http://links.lww.com/MPG/C673*.

DISCUSSION

FLIP has been extensively studied in adult patients with EGJ obstruction when EGJ distensibility is being used to diagnose achalasia or to determine the need for dilation (1,3,11–14). Its role, however, in determining the presence or absence of dysmotility is limited in adults, and has not been studied in pediatrics and there are few studies validating the use of FLIP compared with HRM beyond comparisons of the IRP and EJ distensibility (15,16). This is the first study in adults or children to compare FLIP-induced peristaltic parameters to bolus clearance measured by HRIM. In this present study, we go beyond the prior studies to describe peristaltic parameters seen on FLIP, compare FLIP-peristalsis to HRIM, and compare bolus flow by HRIM to EGJ and peristaltic function by FLIP. We show that effective RACs can, in fact, serve as a proxy for effective clearance, which now opens the door for FLIP to be used as a potential screen for dysmotility. Recognizing the discrepancy between primary and secondary peristalsis, however, if a patient has persistent symptoms despite maximum medical therapy, HRIM may be indicated even with normal RACs. We also show, however, that 42% of patients without RACs have some evidence of peristalsis by HRIM suggesting that while FLIP can be a screen for dysmotility, HRIM must still be performed to confirm a diagnosis.

TABLE 2. The relationship between esophagogastric junction relaxation and bolus flow

	No relaxation	Any relaxation	P value
Bolus flow time-liquid	1.1 ± 0.7	1.8 ± 1.7	0.1
Bolus flow time-viscous	0.8 ± 0.7	3.4 ± 1.8	0.004
Bolus flow time-solid	0.9 ± 1.3	3.2 ± 2.3	0.04
Bolus presence time-liquid	2.3 ± 1.0	4.6 ± 2.7	0.009
Bolus presence time-viscous	2.1 ± 0.6	5.3 ± 1.5	0.005
Bolus presence time-solid	2.5 ± 1.6	5.8 ± 1.8	0.006

TABLE 3. Relationship between repetitive antegrade contraction presence and bolus flow parameters by high-resolution impedance manometry (achalasia patients excluded)

	No RAC	RAC	P value
DCI-liquid, mmHg cm seconds	223 ± 291	669 ± 571	0.09
DCI-viscous, mmHg cm seconds	247 ± 202	675 ± 503	0.11
DCI-solid, mmHg cm seconds	299 ± 306	935 ± 946	0.1
DCV-liquid, cm/seconds	7.3 ± 7.2	4.2 ± 1.3	0.08
DCV-viscous, cm/seconds	6.7 ± 2.5	4.9 ± 1.2	0.13
DCV-solid, cm/seconds	4.1 ± 1.2	4.6 ± 1.2	0.6
DL-liquid, seconds	6.1 ± 0.3	6.5 ± 1.3	0.5
DL-viscous, seconds	5.4 ± 1.1	6.7 ± 1.0	0.15
DL-solid, seconds	5.8 ± 0.9	6.7 ± 1.2	0.2
Largest break-liquid, cm	7.5 ± 8.5	1.5 ± 2.7	0.01
Largest break-viscous, cm	5.0 ± 6.9	2.3 ± 3.7	0.4
Largest break-solid, cm	6.9 ± 8.3	1.9 ± 3.9	0.15
Pressure flow index-liquid	78 ± 95	43 ± 53	0.4
Pressure flow index-viscous	191 ± 232	82 ± 101	0.3
Pressure flow index-solid	160 ± 167	166 ± 253	0.9
Bolus presence time-liquid, seconds	2.4 ± 1.0	4.5 ± 2.8	0.049
Bolus presence time-viscous, seconds	2.3 ± 0.6	5.3 ± 1.7	0.008
Bolus presence time-solid, seconds	2.7 ± 1.7	5.8 ± 1.9	0.02
Bolus flow time-liquid, seconds	1.0 ± 1.2	1.8 ± 1.6	0.4
Bolus flow time-viscous, seconds	0.6 ± 0.8	3.4 ± 1.9	0.03
Bolus flow time-solid, seconds	1.1 ± 1.5	3.2 ± 2.3	0.08

DCI = distal contractile integral, DCV = distal contraction velocity, DL = distal latency, RAC = repetitive antegrade contractions.

Using FLIP to diagnose and screen for dysmotility has appeal in pediatrics as the test can be performed under anesthesia, which allows its performance during routine endoscopy, eliminates the need for patient cooperation, and improves procedural discomfort. Although small studies with FLIP have been done in children to fine-tune the technique with respect to balloon size and to determine the impact of FLIP on the measurement of EGJ distensibility, there are no publications comparing panometry-visualized peristalsis to bolus transit measured during HRIM (1–3).

As has been previously shown, understanding dysmotility is more complex than just the presence or absence of peristalsis; bolus transit is as important particularly in patients with dysphagia or extraesophageal symptoms where there may be a discrepancy between transit and motility (4,5). Our study, therefore, adds to the literature as it is the first to show that a normal panometry correlates with normal bolus clearance too. The fact that patients with RACs have normal bolus clearance by HRIM reflects the fact that secondary peristalsis requires intact neurologic function in the esophageal body (8). This relationship is, however, imperfect; we found that 42% of patients with absent RACs had clear peristalsis by HRIM; in this small number of patients, BPT was relatively preserved (mean BPT: 3.2 ± 1.2 seconds). Similar findings related to the peristaltic abnormalities have been previously described in adults. In a study by Carlson et al of 164 adults with normal HRM who also underwent FLIP, they found that despite the normal HRM with normal IRPs, 27% had abnormalities of distension or relaxation of the EGJ (16). Although this adult study proposes new potential patterns of EGJ dysfunction and peristalsis defined using FLIP, what is lacking in their data is the relationship between FLIP abnormalities and esophageal transit. Do the 1/4 of patients with abnormal EGJ function by FLIP have impairments in transit? This is a critical question as 80% of the patients in this adult study had dysphagia suggesting some impairment in bolus flow. Recent work by Carlson et al have tried to further define conditions where there are discrepancies in diagnostic testing results. In a study of 329 adults undergoing HRM, FLIP, and timed barium esophagram (TBE, using a protocolized method of giving liquid barium followed by a barium pill if the prior was abnormal), FLIP and HRM yielded discrepant results in 12% of patients (17). In these patients, TBE was consistent with FLIP results in 78% of cases and with HRM in 23% of cases suggesting that FLIP may be indicative of functional impairment more than HRM (17). Comparable studies are needed in pediatrics but bolus transit measured by HRIM may be an alternative to TBE and would, in the case of pediatrics, spare the need for additional testing if HRIM is already being performed.

We overcome the limitation of the study by Carlson et al by pairing FLIP observations with bolus transit measures using HRIM. We find that while partial or full EGJ relaxation by FLIP translates into more effective bolus flow, EGJ function is not the whole story with respect to flow. What is now needed, in a large patient series, is to determine if the newly defined EGJ disorders by Carlson et al truly result in impaired transit. Our data suggests that these abnormal findings during panometry may not necessarily result in significant functional impairment as defined by bolus transit.

Apart for EGJ dysfunction, bolus flow is determined by peristaltic integrity. In this study, we show that peristaltic integrity by FLIP correlates with bolus flow by HRIM and that subtle changes in peristalsis (eg, change in the rate of RACs) may be a harbinger of impaired transit such that, if seen at the index endoscopy, may explain symptoms of dysphagia or chronic lung disease resulting from esophageal stasis. We further define the degree of dysfunction needed for bolus flow impairment; even reductions in the speed of RACs could impact bolus flow. In the above mentioned study from Carlson et al (16) of adults with normal HRM who also underwent FLIP, 23% of patient had abnormalities of peristalsis by FLIP defined as a diminished, disordered, or absent peristaltic response, also showing a discrepancy between panometry and HRM. We also found this FLIP/HRIM discordance where 1/3 patient had RACs but abnormal DCIs by HRIM. As mentioned before, they did not address bolus flow during HRM, so it is not possible to draw a direct conclusion on how effective the bolus clearance was in those patients. More studies to fully understand the significance of secondary peristaltic dysfunction on symptom generation are needed.

Interestingly, when we compare bolus flow parameters to prior pediatric HRIM studies, the degree of bolus impairment in our patient populations was significant and on par with pediatric achalasia patients, and therefore, significantly worse than controls (5); normal BFT values, for example, in a small pediatric series were 4.3 (3.8–5.5) seconds and normal BPT values were 5.1 (4.6–6.3) seconds (5). Our study findings in the normal controls and achalasia patients are similar to previous studies but this is the first study to report on flow parameters outside of the realm of achalasia (5); we report on flow parameters in fundoplication patients and in patients with dysmotility for the first time, highlighting a comparable degree of bolus flow impairment to achalasia patients, indicating the complex integration between EGJ function and peristalsis.

There are several limitations to this study. First, unlike adult studies, it is not ethically possible to perform HRIM or FLIP in healthy children so, while it is possible to correlate HRIM with FLIP, clarifying normal FLIP values as they correlate with HRIM in asymptomatic pediatric patients will not be possible. Given this limitation, however, we are able to begin to define the interrelationship between pediatric dysmotility by both diagnostic techniques. Another limitation is the potential impact of anesthesia on FLIP results that are not seen with HRIM in awake patients. We know from our experience that inhalational agents, such as sevoflurane or infused agents, such as dexmedetomidine impact FLIP recording (ie, smooth muscle relaxation, and obliteration of secondary peristalsis and/or changes in EGJ relaxation). Despite this, very few FLIP papers address the anesthesia concerns. In an adult study of 50 adult patients undergoing laparoscopic surgery, authors comment that there was no impact of anesthesia on EGJ distensibility but the types of anesthesia were not discussed nor were there serial measurements before and after change of anesthetic agents to determine the true impact of anesthesia; more importantly they did not perform panometry. In the most recent study of RACs by Carlson et al, patients received midazolam/fentanyl and occasionally propofol but there is no data about differing FLIP results depending on the sedation used. All our studies were performed under propofol and fentanyl as needed. This lack of the effect of sedation/anesthesia in pediatric and adult data represents an opportunity for future study. A final limitation is the limited study sample size though the size is on par with other pediatric studies and despite this, we were able to show clear relationships between motility parameters by FLIP and esophageal function by HRIM.

CONCLUSIONS

In conclusion, we show that FLIP can serve as a screening tool for dysmotility and both EGJ and peristaltic parameters could portend poor esophageal bolus clearance. The next critical step is to determine what is the clinical significance of secondary peristalsis, and if, in disorders beyond achalasia, FLIP parameters correlate with therapeutic outcomes.

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