Measurement of Stricture Dimensions Using a Visual Comparative Estimation Method With Biopsy Forceps During Endoscopy

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ABSTRACT

Background: Estimation of the dimensions of endoscopic findings such as stricture diameter is largely subjective. Accurate assessment of stricture dimensions has multiple benefits including facilitating the choice of appropriately sized endoscopic therapies for treating stricture, properly tracking response to endoscopic therapies between procedures, and potentially even predicting outcomes of endoscopic therapy.
Methods: Endoscopies performed in children with repaired esophageal atresia between August 2019 and August 2021 for which both (1) an endoscopic estimate of esophageal stricture diameter obtained by visual comparison with the known dimensions of the biopsy forceps and (2) an intraoperative esophageal fluoroscopy study were performed were included for analysis. Fluoroscopic stricture diameter measurements were manually obtained using a software ruler tool calibrated to the known dimensions of the intraluminal endoscope. Statistical concordance was calculated between the visual diameter estimates and the standard fluoroscopic stricture measurements.
Results: One hundred ninety-one endoscopies were included for analysis. Lin's concordance correlation coefficient was 0.92 (95% confidence interval: 0.89–0.94) between the visual diameter estimates and the fluoroscopic stricture measurements. Correlation was strongest for smaller to mid-sized stricture diameters.
Conclusions: Use of the biopsy forceps as a visual reference of known dimensions enables accurate visual estimation of esophageal stricture diameter during endoscopy using commonly available tools, with high concordance with standard fluoroscopic measurement techniques.

Key Words: endoscopic measurement, esophageal stricture, stricture diameter

(*JPGN* 2023;76: 77–79)

Estimation of the dimensions of endoscopic findings such as polyp dimensions or stricture diameter is largely subjective and at risk for error (1,2). Accurate assessment of stricture dimensions has the benefits of allowing the endoscopic to choose safe and appropriately sized therapeutic interventions for stricture (eg, dilator size, stent dimensions), reliably tracking response to endoscopic therapies at subsequent procedures, and potentially even predicting outcomes of response to endoscopic therapy (3). Here we describe a comparative estimation method of stricture dimension measurement using the commonly available biopsy forceps tool as a visual reference, and compare the performance of this method to the standard radiographic means of dimension assessment. We hypothesized that use of a visual reference to estimate stricture diameter would be associated with high concordance between the visual estimates and the traditional radiographic measurements.

What Is Known

- Visual estimation of stricture diameter during endoscopy is subjective.
- Accurate size estimation of strictures is essential to tailoring endoscopic therapy.

What Is New

- Introduction of biopsy forceps with known dimensions into the visual field permits accurate stricture diameter estimation.
- Visual estimation using the biopsy forceps as a reference is highly concordant with traditional radiographic means of stricture measurement.

METHODS

Endoscopies performed in children with repaired esophageal atresia between August 2019 and August 2021 for which both a visual estimate of esophageal anastomosis diameter and an intraoperative esophageal fluoroscopy study were performed were retrospectively collected and included for analysis. All endoscopies and visual estimates were performed under general anesthesia by 1 of 3 pediatric gastroenterologists (JY, PN, MM) with sub-specialization in the management of esophageal strictures using either Olympus XP-190N or Olympus GIF-H190.

Visual estimations of the esophageal diameter at the surgical esophageal anastomosis were performed by introducing the biopsy forceps through the working channel of the endoscope into the field of view of the anastomosis, and using known dimensions of the closed and open forceps as a visual reference (Fig. 1A). Measurements of the types of biopsy forceps used

Received July 25, 2022; accepted September 2, 2022.
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The authors report no conflicts of interest.

DOI: 10.1097/MPG.0000000000003625

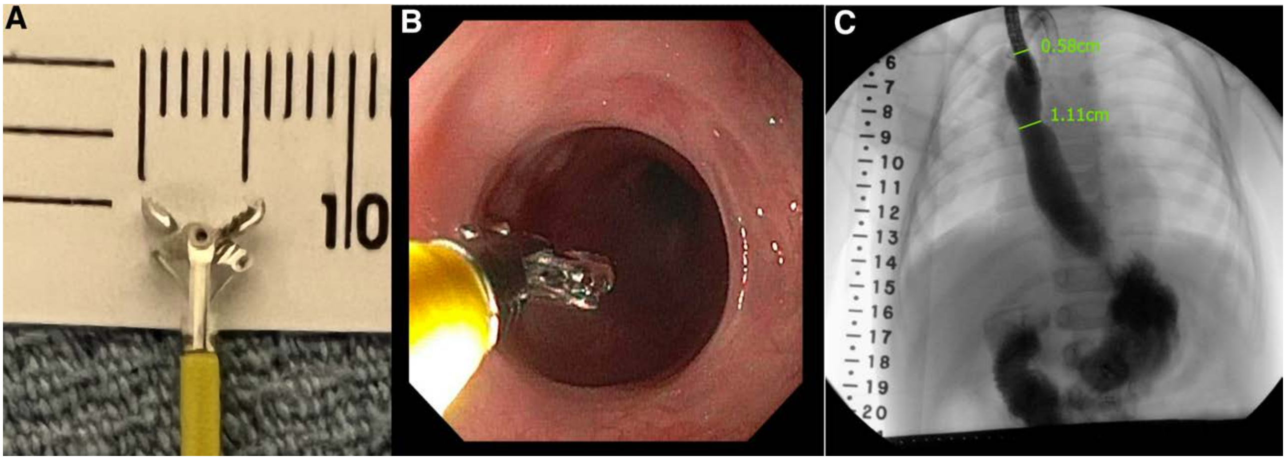

FIGURE 1. (A) Biopsy forceps are of known dimensions (pictured: approximately 6 mm wide for open yellow pediatric forceps; 7 mm wide for open orange standard capacity forceps). (B) The forceps are introduced into the field of view at the level of the esophageal stricture, permitting visual estimation of the size of the stricture diameter (pictured: approximately double the width of the open pediatric biopsy forceps, or 12 mm). (C). Intraoperative esophagram for patient pictured in (B). The radiographic ruler is calibrated to the known dimensions of the endoscope (pictured: Olympus XP endoscope with diameter 5.8 mm). The stricture is then measured with the calibrated software ruler (1.11 cm).

at our institution (Boston Scientific, Marlborough, MA) are as follows: standard biopsy forceps are 2.2 mm wide when closed and 7 mm wide at the jaw tips when open; pediatric biopsy forceps are 1.8 mm wide when closed and 6 mm wide at the jaw tips when open. Estimate of anastomotic diameter is obtained by visual comparison against the known dimensions of the forceps (Fig. 1B). For each patient, a baseline intraoperative fluoroscopic esophagram in the anteroposterior (AP) orientation was performed during the same endoscopy prior to performing any endoscopic stricture therapy by instilling ioversol or iopamidol contrast diluted 1:1 with normal saline and injected into the esophagus via the working channel of the endoscope until the entire esophagus was opacified (Fig. 1C). Radiographs were electronically saved and then manually reviewed by an independent reviewer (GT), and the stricture diameter was measured using a software ruler tool (Synapse v 5.7.220US, Fujifilm Medical Systems USA, Hawthorne, NY) calibrated to the known dimensions of the imaged width of the intraluminal endoscope. Though we routinely obtain fluoroscopy images with a physical radiopaque ruler placed just under the patient, we chose to use the dimensions of the endoluminal scope as the calibration standard for our radiographic stricture measurement as there is some relative magnification of the physical ruler due to its location closer to the fluoroscopy X-ray emitter under the patient compared to the plane of the esophageal stricture.

Concordance between visually estimated endoscopic measurements and radiograph measurements was assessed using Lin's concordance correlation coefficient with 95% confidence interval (CI), with values greater than 0.9 interpreted as indicating very strong concordance and values 0.8–0.9 interpreted as strong concordance. Statistical analyses were performed using Stata (version 16.1, StataCorp LLC, College Station, TX).

RESULTS

There were 191 endoscopies where both visual stricture diameter estimates based on biopsy forceps comparison and intraoperative fluoroscopic stricture measurements were recorded. Lin's concordance correlation coefficient of agreement between the visual estimates and fluoroscopic measurements was 0.92

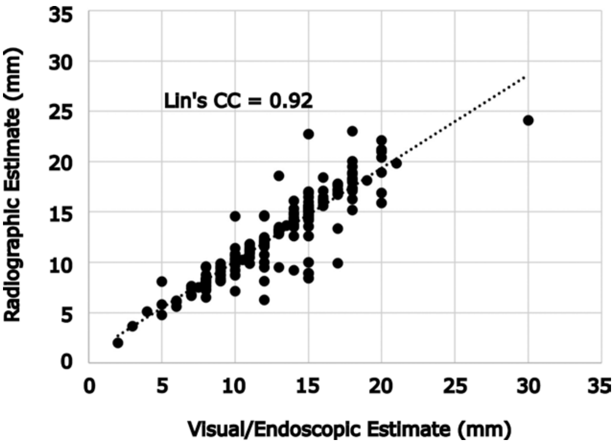

FIGURE 2. Scatter plot of visual stricture diameter estimates obtained via comparison with the biopsy forceps versus the standard radiographic estimate obtained with calibrated ruler measurement.

(95% CI: 0.89–0.94) (Fig. 2). Visual estimates and radiograph measurements were in closer agreement for smaller to mid-sized diameters, with concordance of 0.91 (95% CI: 0.86–0.97) for visually estimated diameters smaller than 10 mm and concordance of 0.83 (95% CI: 0.78–0.88) for estimated diameters greater than or equal to 10 mm.

DISCUSSION

Assessment of esophageal stricture diameter through the endoscope is subjective and at times challenging, as the pediatric esophagus has no inherent consistent visual landmarks for size comparison. Knowledge of the dimensions of the scope itself can be helpful; for example, the ability of a stricture to accommodate passage of either the pediatric (5–6 mm diameter) or standard gastroscope (8.0–9.8 mm) may provide the endoscopist with a rough sense of approximate stricture size (4). Introducing a visual reference such as the biopsy forceps allows for more refined estimation as we demonstrate in the current study. We show in the current study that introducing commonly available tools with known dimensions such as the biopsy forceps allows for a reliable method of visually estimating stricture diameter, with high concordance with simultaneously obtained radiographic measurements of stricture dimensions.

When treating a stricture, the endoscopist is tasked with choosing appropriately sized therapeutic instruments to safely but effectively relieve the narrowing. For example, the American Society for Gastrointestinal Endoscopy Esophageal Dilation Guidelines suggest dilating no more than 3 mm from starting diameter to reduce risk of perforation (5) (though carefully chosen larger dilations in a single session are likely safe in many cases (6,7)); in any case, accurate assessment of starting diameter is key for choosing an appropriate dilator diameter. Similarly, selecting an appropriate stent diameter is critical to balance the need to produce adequate radial force to generate a beneficial effect at the stricture and to reduce chance of stent migration, while also avoiding overly large diameters that may cause major complications from excessive pressure (eg, hemorrhage, perforation, fistula) (8). Assessment of stricture diameter to the single millimeter level in children at high risk for stricture formation after esophageal surgery has been shown to be predictive of outcomes, with children who have smaller stricture diameters at initial-look endoscopy having nearly 13-fold greater odds of failing endoscopic stricture treatment altogether and needing surgical revision (3). While we observed a strong to very strong degree of concordance between visual estimates and radiographic measurements across all stricture diameters, our observed higher concordance of visual estimates and radiograph measurements at small to mid-sized esophageal stricture diameters likely reflects greater ease of visually estimating stricture size when it falls within or close to the dimensions of the biopsy forceps (which can be 1.8–7 mm, depending on standard vs pediatric capacity and closed vs open configuration).

An important benefit of the biopsy forceps method for estimating stricture dimensions is its use of an inexpensive, widely available visual reference tool that does not require additional expensive equipment or training such as endoluminal functional lumen imaging probe (EndoFLIP) or EsoFLIP (Medtronic Inc, Shoreview, MN). There is currently no standard protocol for EndoFLIP or EsoFLIP use in children and is not U.S. Food and Drug Administration approved for use in children younger than 5 years, though there is limited emerging experience to suggest these functional lumen imaging probe technologies are likely safe and can afford the ability to reduce radiation exposure to patients in some settings (9). As per the manufacturer, the use of FLIP catheters is currently not suitable for treatment of strictures smaller than 8 mm, limiting its use in children with very tight strictures. In contrast, the biopsy forceps can be introduced into the endoscopic field of view in any patient in which an endoscope can be introduced, including neonates, and can therefore be a valuable tool for assessment and therapeutic planning for traditional dilations in such patients.

Much of the literature regarding lesion size estimation during endoscopy stems from adult colorectal polyp literature, where the size and morphology of the polyp dictate the recommended method of polyp removal as well as the recommended follow-up surveillance interval (10,11). Estimation of polyp size without use of visual references has repeatedly been shown to be inexact (1,2), with estimation error leading to prescribing incorrect surveillance intervals in 10% of cases in one study (2). Use of visual references such as the biopsy forceps or snare has been shown to improve accuracy (12–14). For example, one head-to-head study (14) of polyp size estimation of 133 polyps in which the endoscopist first visually "eye-balled" polyp size and then subsequently introduced a graduated biopsy forceps for visual reference to re-measure polyp size showed that use of the biopsy forceps significantly improved accuracy of polyp size measurements during endoscopy, improving the ratio between the estimate to actual size from 1.26 ± 0.30 (visual estimate) to 1.02 ± 0.11 (biopsy forcep assisted estimate). None of these visual reference techniques have been previously reported in the literature in the context of measuring strictures.

The present study demonstrates that use of commonly available endoscopic tools of known dimensions is an accurate method of estimating stricture diameter.

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