Indocyanine green enhanced near-infrared fluorescence imaging for perfusion assessment of colonic conduit for esophageal replacement: Utility of a novel technique

Gupta R, Madaan V, Kumar S, Govil D

ABSTRACT

Esophagectomy, followed by esophageal replacement using gastric/colonic conduits, is a complex surgical procedure with significant perioperative morbidity. The most significant and potentially life-threatening complication associated with esophageal replacement is conduit ischaemia, resulting in anastomotic leak and conduit necrosis. Ensuring adequate perfusion of the conduit remains the key to preventing conduit ischaemia. Indocyanine green (ICG) enhanced near-infrared fluorescence imaging is a novel technique which has been used for assessing bowel perfusion. While numerous studies have focused on ICG fluorescence imaging for assessment of gastric conduit perfusion after esophagectomy, data regarding its use for colonic conduits is limited to case reports. ICG fluorescence imaging can help in resolving intraoperative issues by predicting the adequacy of colonic conduit perfusion, thereby preventing postoperative morbidity. To the best of our knowledge, this is the first report in Indian literature describing the utility of ICG fluorescence imaging for assessment of perfusion of colonic interposition.

Case Description

A 22-year-old female had undergone partial gastrectomy with feeding jejunostomy 9 months back, for gastric necrosis with perforation following corrosive ingestion. She was now planned for colonic interposition for absolute dysphagia secondary to long segment corrosive esophageal stricture. Colonoscopy and CT abdominal angiography were normal.

Intraoperatively, ascending, transverse, and descending colon were mobilized in preparation for a right colonic conduit (ascending and right transverse colon) supplied by the marginal arcade through left colic artery. Although in the present case, colonic conduit was performed for a benign indication, the primary aim of presenting this case is to highlight the utility of ICG FI during colonic interposition, which constitutes an important step during esophago-gastrectomy for benign as well as malignant conditions.
perfusion. We, therefore, decided to perform ICG FI. A bolus
of 0.1 mg/kg ICG solution was administered intravenously
and fluorescence was visualized under near-infrared light.
Within 45 s, uniform fluorescence was noticed at the proximal
end of conduit [Figure 1b]. Fluorescence was homogenous
and similar in intensity as compared to remaining colon.
Following substernal transposition to the neck, the ascending
colon appeared congested [Figure 1c]. All mechanical factors
were ruled out. Repeat fluorescence imaging was performed
which showed homogenous perfusion at the tip of the
conduit [Figure 1d]. End to side, hand-sewn, esophago-colic
anastomosis was performed [Figure 1e]. Fluorescence imaging
after the anastomosis confirmed adequate perfusion [Figure 1f].
Distally, roux-en-y colo-jejunal anastomosis, and ileo-colic
anastomosis were performed with feeding jejunostomy.

Postoperative course was uneventful. Swallow study on
postoperative day 10 [Figure 2] revealed no leak, following which
she was started on oral feeds.

Discussion

ICG enhanced near-infrared fluorescence imaging has emerged
as a useful technique for assessment of bowel perfusion. While
the role of ICG FI for assessing perfusion of gastric conduits
has been published extensively, literature regarding its use for
colonic conduits is sparse. Extensive search revealed fewer
than five cases worldwide and no cases in Indian literature,
describing the use of ICG FI for colonic conduits.\(^{[1-3]}\) This
may be because colonic conduit is used only when stomach is
not available for reconstruction. Thomas et al.\(^{[4]}\) reported that
colonic interposition constitutes only 18.5% of all procedures
for esophageal replacement.

A recent meta-analysis revealed that ICG FI results in
decreased anastomotic leaks and graft necrosis following
esophagectomy.\(^{[5]}\) Shimada et al.\(^{[6]}\) and Kesler et al.\(^{[7]}\) reported the
earliest experiences with ICG use for assessment of colonic
conduit. However, recently, Weisel et al.\(^{[8]}\) were the first to report
the technical description of ICG FI for assessing perfusion of
colonic conduit.

The importance of pulsatile flow in the marginal arcade
supplying the conduit has been well described.\(^{[6,7]}\) Although early
studies revealed highest rates of conduit ischemia (~13.3%) with
colonic interposition, recent data suggests that the prevalence is
similar for gastric and colonic conduits.\(^{[8]}\) Nevertheless, conduit
ischemia and necrosis is a difficult situation to manage.

Apart from postoperative morbidity resulting from conduit
necrosis, another important consideration is that further options
for reconstruction are limited. Therefore, all measures must
be taken intraoperatively to confirm adequate vascularization
of the colonic conduit. The use of supercharged conduit or
jejunal interposition has been suggested in case of suspected
conduit hypo-perfusion.\(^{[2,8]}\) By confirming the findings of clinical
assessment, ICG FI may help in deciding whether such steps
are warranted or not.

Figure 1: (a) Assessing pulsations at proximal end of the conduit after trial
clamping of middle colic, right colic & branch between ileo-colic & right
colic artery (bulldog clamps seen in situ); (b) homogeneous fluorescence
noted after administration of ICG; (c) appearance of the tip of conduit in the
neck: conduit appears congested in visible light; (d) intense fluorescence
under near-infrared light with ICG fluorescence imaging; (e) appearance
after the anastomosis under visible light: C (colon), E (esophagus); (f)
appearance after the anastomosis using ICG fluorescence imaging: C
(colon), E (esophagus).

This report is relevant from an Indian perspective, given the fact
that colonic interposition is a common procedure for esophageal
replacement for corrosive esophageal strictures, which form an
important benign cause of dysphagia in developing countries.\(^{[9]}\)
Moreover, a rising trend of esophago-gastric junction carcinoma
has been reported recently from a tertiary care center in India.\(^{[10]}\)
Such lesions often require an esophago-gastrectomy with colonic
conduit. Therefore, the number of cases requiring creation of
a colonic conduit with adequate intraoperative assessment of
conduit perfusion, appears to be on the rise.

Conclusion

ICG fluorescence imaging appears to be a valuable technique
for assessment of colonic conduit perfusion during esophageal
replacement. When there is clinical concern regarding
perfusion, fluorescence imaging can confirm or refute the
findings of clinical evaluation. Conduit hypo-perfusion based
on fluorescence imaging may suggest the need for intraoperative
measures to improve vascularity of the conduit. It can, thus,
help in avoiding postoperative morbidity resulting from conduit ischemia and necrosis. Our case highlights the usefulness of ICG FI for colonic conduit during difficult intraoperative situations. However, larger studies are required to further clarify its role in decreasing anastomotic leaks & conduit necrosis.

Declaration of patient consent
The authors certify that appropriate patient consent was obtained.

Financial support and sponsorship
Nil.

Conflicts of interest
There are no conflicts of interest.

References

1. Shimada Y, Okumura T, Nagata T, Sawada S, Matsui K, Hori R, et al. Usefulness of blood supply visualization by indocyanine green fluorescence for reconstruction during esophagectomy. Esophagus 2011;8:259-66.
2. Kesler KA, Pillai ST, Birdas TJ, Rieger KM, Okereke IC, Ceppa D, et al. “Supercharged” isoperistaltic colon interposition for long-segment esophageal reconstruction. Ann Thorac Surg 2013;95:1162-8.
3. Wiesel O, Shaw JP, Ramjist J, Brichkov I, Sherwinter DA. The use of fluorescence imaging in colon interposition for esophageal replacement: A technical note. J Laparoendosc Adv Surg Tech A 2020;30:103-9.
4. Thomas P, Fuentes P, Giudicelli R, Reboud E. Colon interposition for esophageal replacement: Current indications and long-term function. Ann Thorac Surg 1997;64:757-64.
5. Slooter MD, Eshuis WJ, Cuesta MA, Gisbertz SS, van Berge Henegouwen MI. Fluorescent imaging using indocyanine green during esophagectomy to prevent surgical morbidity: A systematic review and meta-analysis. J Thorac Dis 2019;11(Suppl 5):S755-65.
6. Chang AC. Colon interposition for staged esophageal reconstruction. Oper Tech Thorac Cardiovasc Surg 2010;15:231-42.
7. Fürst H, Hartl WH, Löhe F, Schildberg FW. The use of fluorescence imaging in colon interposition for esophageal replacement: An alternative technique based on the use of the right colon. Ann Surg 2000;231:173-8.
8. Athanasiou A, Hennessy M, Spaltalis E, Tan BHL, Griffiths EA. Conduit necrosis following esophagectomy: An up-to-date literature review. World J Gastrointest Surg 2019;11:155-68.
9. Ananthakrishnan N, Subbarao KS, Parthasarathy G, Kate V, Kalayarasan R. Long-term results of esophageal bypass for corrosive strictures without esophageal resection using a modified left colon esophaugocoloplasty—A report of 105 consecutive patients from a single unit over 30 years. Hepatogastroenterology 2014;61:1033-41.
10. Choisi D, Kolhe KM, Ingle M, Rathi C, Khairnar H, Chauhan SG, et al. Esophageal carcinoma: An epidemiological analysis and study of the time trends over the last 20 years from a single center in India. J Family Med Prim Care 2020;9:1695-9.