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The novel use of intraoperative laser-induced fluorescence of indocyanine green tissue angiography for evaluation of the gastric conduit in esophageal reconstructive surgery

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Abstract

BACKGROUND: Esophagectomy with reconstruction using a gastric conduit is associated with a relatively high rate of anastomotic leakage. We used indocyanine green tissue angiography to evaluate the gastric conduit intraoperatively before gastroesophageal anastomosis to identify ischemia.

METHODS: We performed an institutional review board–approved retrospective review of all esophagectomies performed from 2010 to the beginning of 2011. Patient histories and perioperative outcomes were reviewed retrospectively. Postoperative morbidity and 30-day mortality were determined.

RESULTS: Eleven patients had an esophagectomy performed using this technology. All had adequate perfusion on gross examination. All but 1 had good perfusion with tissue angiography, and there were 2 anastomotic leaks including this patient. There were no mortalities at 30 days.

CONCLUSIONS: We report preliminary results using this imaging system in esophageal reconstructive surgery. Larger randomized controlled studies are needed to determine if surgical outcomes can be improved using this technology.

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fulminant leak has up to a 90% mortality rate, whereas delayed leaks have anywhere from a 20% to 60% mortality rate depending on the location of the anastomosis. Intrathoracic anastomoses are associated with a higher morbidity and mortality although they have a lower rate of anastomotic leakage. Cervical anastomoses leak more often but have a lower associated morbidity. Survivors of an anastomotic leak are prone to developing anastomotic strictures, a frustrating and costly complication that is estimated to occur in up to 63% of postesophagectomy patients.

Some level of devascularization is inherent to the operation. The stomach is devascularized with the exception of the right gastric and right gastroepiploic arteries. The right gastric artery has been shown to contribute minimal blood flow to the conduit with most of the perfusion provided by the right gastroepiploic artery. In addition, it has been shown that the blood supply to the fundus of the stomach, the very area of the stomach included in esophagogastric anastomosis, is supplied only by a submucosal plexus of vessels.

The most common method of determining the perfusion and viability of the surgically created gastric conduit is clinical judgment. However, this has been shown to correlate poorly with clinical results. There are several other methods for evaluating the gastric conduit and the finished anastomosis (Table 1), each with its own set of advantages and disadvantages. Laser-induced indocyanine green using the commercially available SPY Imaging System (Novadaq Industries Inc, Toronto, Canada) is a technology that allows the performance of real-time tissue angiography of the tissue in question. This technology has been used with success in both cardiac surgery and plastic and reconstructive breast surgery. The imaging system consists of a console, a camera, a camera arm, a display monitor, and a computer.
Results

Methods

We performed an institutional review board–approved retrospective review of all of the esophagectomies performed since we began using the SPY Imaging System, which was from 2010 to early 2011. The preoperative workup, intraoperative findings, and the postoperative course were reviewed. Operative notes and SPY camera images were reviewed to determine the surgeon’s clinical assessment of the perfusion to the conduit before formation of the anastomosis both grossly and with the use of the SPY Imaging System. A chart review was performed to determine morbidity and 30-day mortality. Leaks were determined to be present if there were clinical signs of a leak at the neck incision, if the incision was opened, or if a leak was shown on an esophagram. All patients had an esophagram before oral intake was initiated.

Results

Eleven patients underwent esophagectomy with the aid of the SPY Imaging System. The average patient age was 56.4 ± 8.9 years (range 47–72 years). Carcinoma was biopsy proven, and upper gastrointestinal endoscopy was performed in all patients. Seven of 11 patients (64%) received neoadjuvant chemotherapy and radiation. All patients underwent a transhiatal approach with a single-layer, handsewn cervical gastroesophageal anastomosis. The average intraoperative time was 231.7 ± 30 minutes (range 191–289 minutes). All patients had biopsy-proven adenocarcinoma except for 1 patient who had squamous cell carcinoma. The estimated blood loss was 486 mL (range 200–1,200 mL). On gross examination, there was good perfusion noted in the operative report of all 11 patients. Ten of the 11 patients showed good perfusion when using the SPY Imaging System (Fig. 1). There were no revisions in any conduit before anastomosis. There were 2 leaks, which were both diagnosed clinically. Both patients were noted to have had a change in character of the JP output and erythema at the neck incision, and these were opened at the bedside on postoperative days 5 and 6, respectively. All other patients without clinical signs of a leak had esophagrams that failed to show an anastomotic leak before initiating oral intake. Our overall leak rate for the study was 2 of 11 patients (18%). Other postoperative complications included 2 patients who went into atrial fibrillation; they were both treated medically and both returned to normal sinus rhythm. One patient had difficulty swallowing after the operation and was treated with speech therapy. The average length of stay was 14.4 ± 4.8 days (8–22 days). There were no complications related to the use of the SPY Imaging System.

Comments

There are many methods available to evaluate tissue perfusion as previously mentioned. These include the fluorescein/Wood lamp combination, conventional Doppler, laser Doppler flowmetry, single-photon emission computed tomography, mucosal oxygen saturation, conventional angiography, computed tomography angiography, and esophagogastroduodenoscopy. Each has its limitations. Technologies such as conventional Doppler/duplex have the advantage of being inexpensive but only represent the microvasculature. As previously discussed, it is the microvasculature of the most caudal pedicle of the gastric conduit that is used in the anastomosis that is important. Laser Doppler, which required tissue contact to determine perfusion on a microvasculature level, only represents the actual 0.5 cm² area of tissue below the probe. Thus, one of its shortcomings is that it fails to give the operating surgeon the “big picture” of the overall perfusion. Several other technologies have this same limitation. Computed tomographic scans and early endoscopy have been reported but offer “after-the-fact” data because they are not practical for use in the operating room in this setting. SPY camera imaging using indocyanine green is readily available in...
Esophageal surgery continues to evolve. Still, there is a relatively high rate of morbidity and mortality associated with anastomotic leaks in esophageal reconstructive surgery. We report our initial experience using laser-induced indocyanine green tissue angiography intraoperatively for esophageal reconstructive surgery. Although this is a small and retrospective feasibility study, we believe that the technology might be useful in this setting. Its use warrants further study in a prospective and randomized fashion. This study also has stirred some interest in using the technology for other gastrointestinal anastomoses. Currently, we are enrolling patients in a randomized controlled trial to evaluate the use of this technology in colorectal anastomoses. Undoubtedly, additional study is needed in this area before its use can be advocated routinely in gastrointestinal surgery.

**Conclusions**

Esophageal surgery continues to evolve. Still, there is a relatively high rate of morbidity and mortality associated with anastomotic leaks in esophageal reconstructive surgery. We report our initial experience using laser-induced indocyanine green tissue angiography intraoperatively for esophageal reconstructive surgery. Although this is a small and retrospective feasibility study, we believe that the technology might be useful in this setting. Its use warrants further study in a prospective and randomized fashion. This study also has stirred some interest in using the technology for other gastrointestinal anastomoses. Currently, we are enrolling patients in a randomized controlled trial to evaluate the use of this technology in colorectal anastomoses. Undoubtedly, additional study is needed in this area before its use can be advocated routinely in gastrointestinal surgery.

**References**


**Discussion**

Gerard V. Aranha, M.D. (Maywood, IL): If there is a Holy Grail in esophageal surgery, it is 0% leak rate. Pa-

checo et al have brought to us a new technique to display imaging systems and said that it might help us reduce, but have they shown us that? I don’t think so. If you take your 2 leaks, that’s 18%, but then you take away the
1 patient who had full blood supply, he’s still 10%, which is a median leak rate for transhiatals. I do more Whippets than I do esophageal surgery, and I do the traditional Whipple where I do gastrectomy. I’m very impressed with the robust right gastric that I see in many patients. So do you preserve the right gastric? The leaks most often occur at the anastomosis, but they can occur at the staple line or at the very tip of the conduit. Is your camera able to tell you the whole area? In Europe, they do what is known as gastric ischemic conditioning where they go in with the laparoscope; they can use that to tell if there is metastasis and also ligate the left gastric artery and allow for equal access. What do you think of that technique?

Sean M. Hill, M.D. (Peoria, IL): Regarding the right gastric vessel, we actually do not save this for esophagectomies. The SPY camera shows the whole conduit, so there’s no problem evaluating that. Regarding gastric conditioning, I think that is an excellent thought. I know this has been used in several other surgical specialties, so I think that gastric conditioning could be something that could be used in the future to reduce the leak rate.

Margo C. Shoup, M.D. (Maywood, IL): This is a very interesting pilot study; I would call it that at this point. Dr Aranha and I perform all the esophagectomies at Loyola, and it’s very rare for us to have a major problem from a leak. Like you showed here, they leak. That’s fine. They get stenosed; they get dilated. It’s not usually a major issue. So I guess my question is I know you only had 11 patients in your study, but 2 things. With the recent data that were presented at the American Society of Clinical Oncology GI in January, it appears that everybody with esophageal cancer benefits from neoadjuvant chemoradiation with the exception of the T1 and 0s that we just don’t see that much of in this country. At what point would you use this technique? Would you use the SPY camera to identify reduced blood flow? We operate on these patients 4 to 6 weeks after their radiation, sacrifice the left gastric artery, wait 6 more weeks for reperfusion, and take them back. We get a little nervous thinking we are going to operate on the esophagus 12 weeks after radiation. It kind of makes it a little more of a difficult operation, and patients don’t usually like to wait that long in the first place. Is there going to be a difference based on the patients who had chemoradiation or not, or is there a difference in the age of your patients who leaked? I am going to have a very difficult time convincing my institution to purchase a $250,000 piece of equipment for such a rare complication unless we can justify it.

Dr Hill: Actually, based on our 11 patients, the one who had clinically poor blood flow by the SPY camera was actually a patient who had not received neoadjuvant therapy. This patient was kind of in the median to younger age range of all of our patients. Regarding everyone else, counterintuitively, you would think there would be poor blood flow because of radiation or chemotherapy, but in this case it was not seen in our 10 patients. Regarding the cost of the machine itself, it is quite expensive, but as I have discussed, this is used by several specialists throughout our institution. It is actually used by our plastic surgeons, our thoracic surgeons, and our colorectal surgeons now.