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Case report

INTRAOPERATIVE APPLICATION OF INDOCYANINE GREEN IN CANINE METASTATIC INTESTINAL ADENOCARCINOMA

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A 12–year–old castrated male mongrel was presented with an intestinal mass, weight loss, and hematochezia. Diagnostic imaging identified a soft tissue mass in the ileum and two enlarged intra–abdominal lymph nodes. Surgical resection was performed with intraoperative guidance using near–infrared fluorescence (NIRF) imaging and indocyanine green (ICG). The tumor exhibited reduced fluorescence compared to the surrounding intestine, enabling negative contrast–based visualization of the resection boundary and preservation of the ileocecal valve. Submucosal injection of ICG intraoperatively allowed clear visualization of lymphatic drainage and identification of a fluorescent sentinel lymph node (SLN). Histopathological examination confirmed complete excision of an invasive adenocarcinoma with tumor–free margins. The fluorescent lymph node was metastatic, while the non–fluorescent enlarged node was benign adipose tissue. The patient recovered uneventfully, with no recurrence or metastasis observed at the one–year follow–up. This case demonstrates the clinical utility of ICG–NIRF imaging in guiding margin assessment and SLN mapping during intestinal tumor surgery in a dog. The approach facilitated more accurate staging and conservative resection, potentially reducing surgical morbidity. This case report describes the first documented veterinary case of ICG–NIRF–guided resection and SLN mapping for canine intestinal adenocarcinoma.

Keywords: dog, guided tumor resection, indocyanine green, intestinal adenocarcinoma, sentinel lymph node mapping

INTRODUCTION

Canine intestinal neoplasms, predominantly adenocarcinomas, leiomyosarcomas, and lymphomas, represent approximately 8% of all tumors diagnosed in dogs [1]. Common clinical manifestations include vomiting, diarrhea, anorexia, weight loss, abdominal discomfort, hematochezia, and in more advanced cases, intestinal obstruction, or perforation [2]. Diagnosis is based on radiograph, abdominal ultrasonography,

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computed tomography (CT), and biopsy. At the time of diagnosis, metastasis is observed in roughly 50 – 80% of canine intestinal tumor cases, most frequently affecting mesenteric lymph nodes, liver, spleen, peritoneum, and lungs [3,4]. Complete surgical resection and anastomosis, involving at least 3 cm of grossly normal intestinal tissue, is the treatment for solid masses, neoplastic obstructions, and stenotic lesions [2]. Although the presence of lymph node metastasis correlates with a less favorable prognosis, surgical intervention is still considered beneficial for managing local disease progression [3,4].

Near–infrared fluorescence (NIRF) imaging has emerged as a promising intraoperative technique in both human and veterinary medicine. This method involves the use of fluorescent dyes that emit light when activated by near–infrared wavelengths, enhancing intraoperative visualization of tissues. Indocyanine green (ICG), a clinically approved contrast agent, fluoresces at a peak wavelength of approximately 822 nm [5]. In veterinary surgical practice, ICG–NIRF imaging has been explored for tumor resection guidance and sentinel lymph node (SLN) identification [6–8].

This case report aims to illustrate the application of ICG–based NIRF imaging for accurate surgical margin assessment and SLN detection in a dog diagnosed with intestinal adenocarcinoma.

CASE PRESENTATION

A 12–year–old castrated male mongrel dog, weighing 5.76 kg, was referred to Chungbuk National University Veterinary Teaching Hospital due to an abdominal mass on radiography. The patient had exhibited progressive weight loss, intermittent vomiting, and hematochezia over the preceding two months. Physical examination revealed no significant abnormalities. A complete blood count, serum chemistry, and blood gas analysis revealed no significant abnormalities except for hyoalbuminemia (2.4 g/dL; reference range: 2.6–3.3 g/dL) and increased alkaline phosphatase (716 IU/L; reference range: 29–97 IU/L).

Radiographic evaluation showed decreased serosal detail in the cranial abdomen, with irregular small intestine wall margins. A soft tissue–density mass, approximately 16 × 13 mm in size, was noted at the lateral aspect of the third lumbar vertebra. Abdominal ultrasonography identified a large, well–demarcated, heterogenous mass (46.3 × 23.8 × 24.7 mm) localized to the left caudal abdomen, suspected to originate from the jejunum or ileum. The mass displayed disrupted wall layering and was surrounded by mildly hyperechoic and edematous peritoneum. Adjacent bowel segments showed mild thickening of the muscularis layer. A nearby hypoechoic, elongated lymph node (12.4 × 5.45 mm) was also visualized. To further characterize the lesion and evaluate potential metastatic spread, a contrast–enhanced CT scan was conducted under general anesthesia. CT images confirmed the presence of a soft tissue mass (37.1 × 23.6 mm) located posterior to the right kidney, likely originating from the ileum, with

an estimated length of 7–8 cm (Figure 1A). The mass exhibited heterogeneous post–contrast enhancement. Intra–abdominal lymph nodes appeared moderately enlarged with heterogeneous contrast enhancement. The first lymph node measured 13.5 × 9.80 × 5.60 mm (Figure 1B) and the second lymph node measured approximately 5.20 × 3.35 × 8.64 mm (Figure 1C).

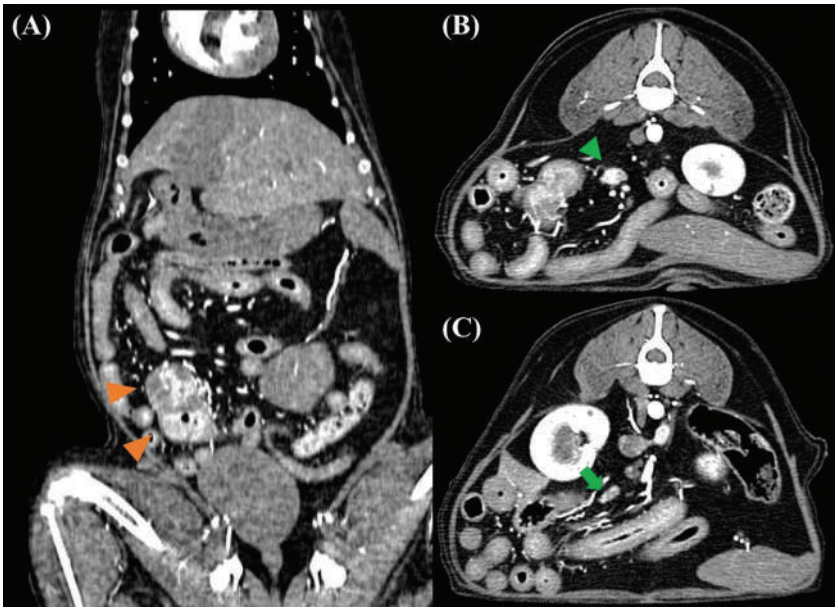

Figure 1. Computed tomography images of the intestinal tumor and enlarged lymph nodes. **(A)** A soft tissue mass (37.1 × 23.6 mm, orange arrowhead) located posterior to the right kidney and likely arising from the ileum, with an estimated total length of 7–8 cm. **(B)** The first enlarged lymph node (green arrowhead) showing contrast enhancement. **(C)** The second enlarged lymph node (green arrow) also exhibiting contrast enhancement.

Surgical excision of the intestinal mass and sentinel lymph node extirpation was performed. For intraoperative guidance, ICG (5 mg/kg) was administered intravenously 24 hours prior to surgery [6]. Anesthesia was induced with intravenous propofol (6 mg/kg) and midazolam (0.2 mg/kg) and maintained with 2.0% isoflurane in 100% oxygen and a continuous infusion of Hartmann's solution (2.5 mL/kg/h). Intraoperative NIRF imaging was performed using a dedicated camera system. The mass (55 × 32 mm) was located in the ileum near the ileocecal valve (Figure 2) and exhibited reduced fluorescence compared to surrounding intestinal segments (Figure 3). Based on the fluorescence boundary, the proximal resection margin was set at 3 cm, while the distal margin was guided by the interface of fluorescence loss. Immediately before resection, a 0.5 mL dose of ICG (2 mg/mL) was injected into the submucosal layer around the tumor. Within 2 minutes, NIRF imaging visualized lymphatic drainage pathways and highlighted the sentinel lymph node (Figure 3). Of the two lymph nodes identified on

CT, only the larger (16 × 15 mm) node exhibited fluorescence. Both the tumor and the lymph nodes were resected. No intraoperative complications occurred.

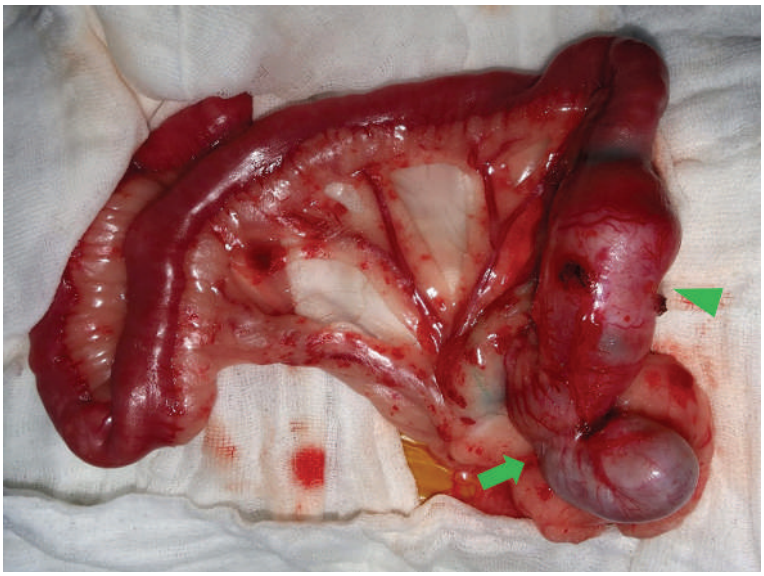

Figure 2. Intraoperative image of the intestinal tumor. The mass (arrowhead) was located on the ileum and situated in close proximity to the ileocecal valve (arrow).

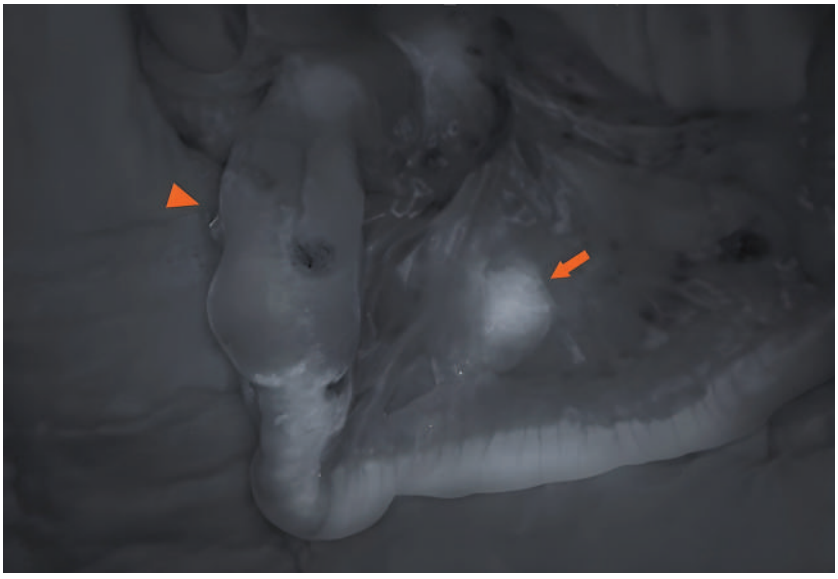

Figure 3. Intraoperative near–infrared fluorescence image of the intestinal tumor. The tumor (arrowhead) demonstrated reduced fluorescence relative to the adjacent tissues, resulting in negative contrast. The sentinel lymph node (arrow) exhibited distinct fluorescence and was confirmed to be metastatic on histopathological examination.

Histopathological evaluation of the specimens confirmed the tumor as an invasive adenocarcinoma with tumor–free resection margins (Figure 4A). The mitotic index was 23 per high–power field, with no vascular invasion identified. The fluorescent lymph node revealed metastatic adenocarcinoma (Figure 4B), while the non–fluorescent enlarged node was composed of well–differentiated adipose tissue (Figure 4C).

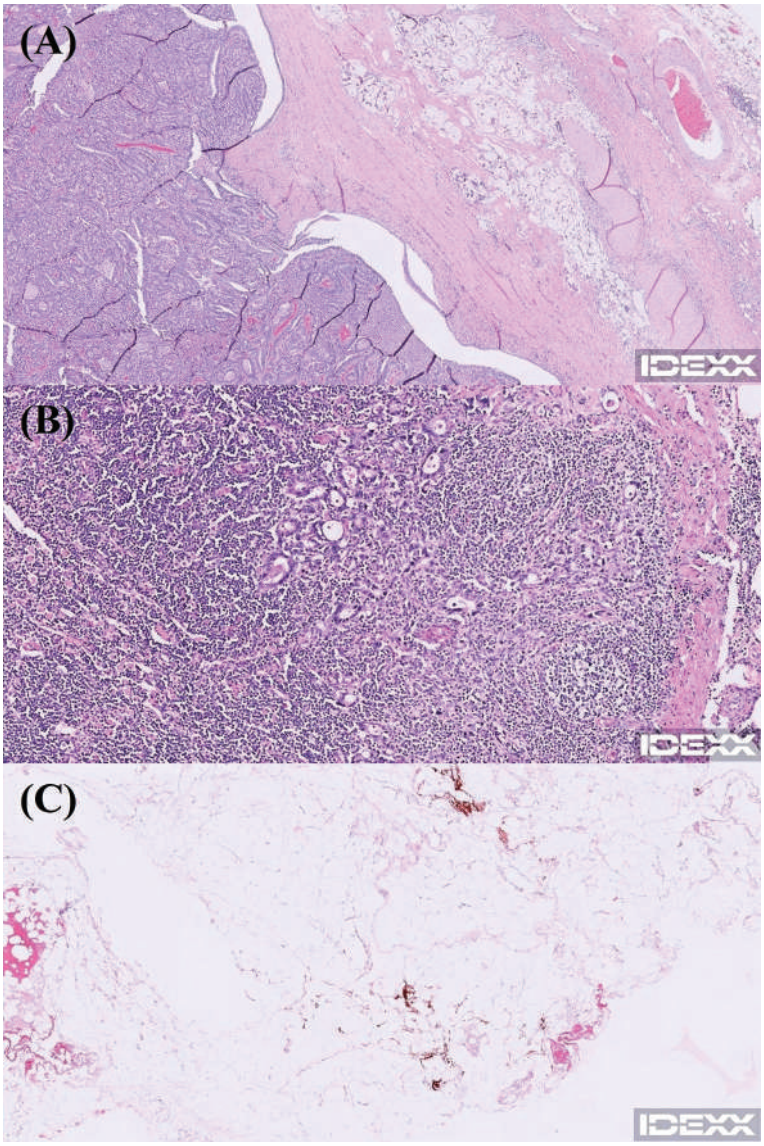

Figure 4. Histopathological images of the intestinal tumor and suspected sentinel lymph nodes (H&E stain). **(A)** Invasive adenocarcinoma infiltrating the intestinal wall with tumor–free resection margins. **(B)** Metastatic adenocarcinoma identified in the fluorescent sentinel lymph node. **(C)** Non–fluorescent enlarged lymph node composed of mature adipose tissue without evidence of neoplastic infiltration.

The patient recovered uneventfully, with normal defecation observed on postoperative day three and discharge on day five. At the one–year follow–up, radiography and ultrasound showed no evidence of recurrence or metastasis. Adjuvant chemotherapy was not pursued due to the owner's decision.

DISCUSSION

This case report demonstrates the first application of ICG–NIRF imaging to guide surgical resection of a canine intestinal tumor. Current surgical guidelines recommend resection with a margin of at least 3 cm of grossly unaffected intestine to ensure oncological clearance [2]. However, distal small intestinal resections are associated with a higher risk of complications and poorer prognosis compared to proximal resections [9]. One of the major complications following intestinal resection is short bowel syndrome, which is influenced by factors such as the amount and location of the resected intestine, presence of the ileocecal valve, and degree of intestinal adaptation [10,11]. Therefore, minimizing the extent of resection while ensuring tumor–free margins is critical in small intestinal surgery. In this case, the application of ICG fluorescence imaging allowed for precise identification of tumor boundaries based on a fluorescence contrast pattern. Notably, the tumor displayed reduced fluorescence compared to adjacent normal intestine. This phenomenon, possibly due to intratumoral ICG aggregation and subsequent quenching, paradoxically enhanced margin visualization by creating negative contrast [5]. As a result, sufficient oncologic margins were achieved without necessitating removal of the ileocecal valve.

Detecting lymph nodes in dogs can be challenging due to their small size and similarity to surrounding tissues. However, intraoperative ICG injection enabled clear visualization of lymphatic drainage from the tumor, allowing precise SLN identification. In human medicine, ICG fluorescence is widely used for SLN mapping in cancers such as colorectal and gastric cancer, showing high accuracy (89–100%) and low false–negative rates (~1%) [12]. These procedures typically involve injecting a 2 mg/mL ICG solution into the submucosa around the tumor and detecting fluorescence with a near–infrared camera. Following similar protocols, this case used submucosal ICG injection, which successfully visualized lymphatic flow and identified a fluorescent SLN [12]. Interestingly, another enlarged lymph node seen on CT lacked fluorescence and was later identified as benign adipose tissue. This highlights potential use of ICG to improve lymphatic mapping specificity, offering more reliable intraoperative guidance than CT alone.

Canine intestinal adenocarcinomas are highly aggressive tumors with frequent metastasis to regional lymph nodes and visceral organs. Prognosis varies, with median survival times reported between 233 and 544 days, and 1–year survival rates ranging from 13% to 60% [3,4,13]. Metastasis at diagnosis is commonly associated with reduced survival, and reported metastatic rates range from 24% to 67% [3,4,13]. Although adjuvant therapy may help extend survival, its effectiveness remains inconsistent and

not well established [13]. Despite the presence of metastasis in this case, outcomes were favorable. The tumor was completely resected with clean margins, the metastatic lymph node was removed, and no recurrence or further metastasis was detected during a year of follow–up.

The limitations of this case include the application of ICG sentinel lymph node mapping in only a single canine case of intestinal adenocarcinoma, necessitating further evaluation of its therapeutic benefits in a larger cohort. Additionally, as this study utilized a single dosage and injection method, further research is required to determine the optimal dosage and injection technique for achieving the most accurate and consistent results.

In conclusion, this case report demonstrates the first application of ICG fluorescence imaging for guided surgical tumor resection and sentinel lymph node mapping in a canine intestinal adenocarcinoma. With further validation, this approach may contribute significantly to improving prognostic evaluation and informing treatment planning for similar cases in the future.

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Authors' contributions

SK performed the conceptualization, data curation, formal analysis, software implementation, visualization, and wrote the original draft. YK participated in the formal analysis, visualization, and reviewed and edited the manuscript. KMP contributed to the formal analysis, supervision, validation, and reviewed and edited the manuscript. SL contributed to the conceptualization, funding acquisition, and writing of the original draft. All authors have read and approved the final manuscript.

Declaration of conflicting interests

The authors declared that there is no conflict of interest.

Statement of informed consent

The owner understood the procedure and agreed that results related to investigation or treatment of their companion animals, could be published in Scientific Journal Acta Veterinaria Beograd.

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REFERENCES

1. Dobson JM, Samuel S, Milstein H, Rogers K, Wood JL: Canine neoplasia in the UK: estimates of incidence rates from a population of insured dogs. J Small Anim Pract 2002, 43(6):240–246.
2. Michelle A, Tobias KM, Johnston SA: Small intestine. In: *Veterinary Surgery: Small Animal. 2nd ed.* St. Louis, USA: Elsevier Health Sciences; 2017, 1730–1760.
3. Crawshaw J, Berg J, Sardinas JC, Engler SJ, Rand WM, Ogilvie GK, Spodnick GJ, O'Keefe DA, Vail DM, Henderson RA: Prognosis for dogs with nonlymphomatous, small intestinal tumors treated by surgical excision, J Am Anim Hosp Assoc 1998, 34(6):451–456.
4. Birchard SJ, Couto CG, Johnson S: Nonlymphoid intestinal neoplasia in 32 dogs and 14 cats, J Am Anim Hosp Assoc 1986, 22(4): 533–537.
5. Reinhart MB, Huntington CR, Blair LJ, Heniford BT, Augenstein VA: Indocyanine Green: Historical Context, Current Applications, and Future Considerations. Surg. Innov 2016, 23(2):166–175.
6. Choi J, Lee S: Excision of a gastrointestinal stromal tumour in a dog using short–wave infrared fluorescence imaging and indocyanine green. Vet Med Sci 2024, 10(4):e1506.
7. Beer P, Rohrer–Bley C, Nolff MC: Near–infrared fluorescent image–guided lymph node dissection compared with locoregional lymphadenectomies in dogs with mast cell tumours. J Small Anim Pract 2022, 63(9):670–678.
8. Kim S, Lee S: Utilization of indocyanine green for intraoperative sentinel lymph node mapping in canine mammary tumors. Sci Rep 2025, 15:8315.
9. Thompson JS, Quigley EM, Adrian TE: Factors affecting outcome following proximal and distal intestinal resection in the dog: an examination of the relative roles of mucosal adaptation, motility, luminal factors, and enteric peptides. Dig Dis Sci 1999, 44(1):63–74.
10. Gorman SC, Freeman LM, Mitchell SL, Chan DL: Extensive small bowel resection in dogs and cats: 20 cases (1998–2004). J Am Vet Med Assoc 2006, 228(3):403–407.
11. Yanoff SR, Willard MD, Boothe HW, Walker M: Short–bowel syndrome in four dogs. Vet Surg 1992, 21(3):217–222.
12. Lim ZY, Mohan S, Balasubramaniam S, Ahmed S, Siew CCH, Shelat VG: Indocyanine green dye and its application in gastrointestinal surgery: The future is bright green. World J Gastrointest Surg 2023, 15(9):1841–1857.
13. Smith AA, Frimberger AE, Moore AS: Retrospective study of survival time and prognostic factors for dogs with small intestinal adenocarcinoma treated by tumor excision with or without adjuvant chemotherapy. J Am Vet Med Assoc 2019, 254(2):243–250.

INTRAOPERATIVNA PRIMENA INDOKCIJANIN ZELENE KOD METASTATSKOG INTESTINALNOG ADENOKARCINOMA KOD PSA

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Dvanaestogodišnji kastrirani mužjak psa mešanca prezentovan je sa promenom u crevima, gubitkom težine i hematohezijom. Dijagnostičkim snimanjem je identifikovana masa mekog tkiva u ileumu i dva uvećana intraabdominalna limfna čvora. Hirurška resekcija je izvršena uz intraoperativno vođenje korišćenjem snimanja bliske infracrvene fluorescencije (NIRF) i indocijanin zelene (ICG). Tumor je pokazao smanjenu fluorescenciju u poređenju sa okolnim crevom, što je omogućilo vizuelizaciju granice resekcije na osnovu negativnog kontrasta i očuvanje ileocekalnog zalistka. Submukozna injekcija ICG intraoperativno je omogućila jasnu vizuelizaciju limfne drenaže i identifikaciju fluorescentnog prvog drenirajućeg (*sentinel*) limfnog čvora (SLN). Histopatološki pregled je potvrdio kompletnu eksciziju invazivnog adenokarcinoma sa marginama bez tumora. Fluorescentni limfni čvor je bio metastatski, dok je nefluorescentni uvećani čvor bio benigno masno tkivo. Pacijent se oporavio bez ikakvih problema, bez recidiva ili metastaza tokom jednogodišnjeg praćenja. Ovaj slučaj pokazuje kliničku korisnost ICG–NIRF snimanja u vođenju procene margina i mapiranja SLN tokom operacije tumora creva kod psa. Pristup je omogućio preciznije određivanje stadijuma i konzervativnu resekciju, potencijalno smanjujući hirurški morbiditet. Ovaj izveštaj o slučaju opisuje prvi dokumentovani veterinarski slučaj ICG–NIRF–vođene resekcije i mapiranja SLN za intestinalni adenokarcinom pasa.