



Iatrogenic celiac and hepatic artery dissections during intra-arterial regional tumor therapies: a 16-year retrospective review

Erica S. Alexander¹ · Gregory J. Nadolski¹ · Michael C. Soulen¹ · S. William Stavropoulos¹ · Stephen J. Hunt¹ · Terence P. Gade¹ · Maxim Itkin¹ · Susan Shamimi-Noori¹

Published online: 30 August 2019
© Springer Science+Business Media, LLC, part of Springer Nature 2019

Abstract

Purpose To identify the incidence and outcomes of iatrogenic celiac and hepatic artery dissections during transarterial therapies, including bland embolization, chemoembolization, radioembolization (TARE), and pre-TARE scintigraphic mapping.

Methods The institution's quality assessment database, electronic medical record, and picture archiving and communication system were reviewed to identify all patients who underwent transarterial locoregional therapy from 1/2001 to 7/2017 and to determine the incidence of iatrogenic dissection, to assess patency of the arteries after dissection, and to assess the ability to complete therapy.

Results 2253 patients underwent 3776 transarterial hepatic oncology procedures. Among 3776 procedures, 40 (1.1%) were associated with dissection of the visceral vasculature, affecting 39 patients (1.7%). The incidence of flow-limiting dissections was 0.3% (13/3776) and non-flow-limiting dissections was 0.7% (27/3776). After dissection, 68% (27/40) of treatments were completed the same day. Among the 13 aborted treatments, 8 (62%) were completed on a subsequent encounter. Follow-up imaging was obtained in 26 of 40 cases at median time of 63 days. Complete resolution of the dissection was seen in 15/26 cases (58%), near complete resolution (< 30% luminal narrowing) in 3/26 (12%), unchanged appearance of a non-flow-limiting dissection in 4/26 (15%), progressive luminal narrowing in 3/26 (12%), and complete occlusion in 1/26 (4%).

Conclusion Iatrogenic dissections of visceral arteries rarely occur during tumor embolization procedures. 35/39 (90%) of patients underwent successful treatment despite the dissection.

Keywords Arterial dissection · Transarterial chemoembolization · Transarterial radioembolization · Bland embolization

Introduction

In 2008, over 10,000 interventional oncology procedures, including ablation and transarterial embolization were performed in the Medicare population [1]. This number continues to grow, as interventional oncologic therapies have become well-accepted treatment options. In patients with primary liver cancers and hepatic metastases, transarterial embolization therapies are mainstays for treating inoperable disease or as a bridge to transplantation [2–4]. Transarterial hepatic radioembolization (TARE), bland embolization

(TAE), and chemoembolization (TACE) are generally well tolerated, with most studies reporting major complication rates less than 5% [5–8].

Iatrogenic arterial injuries, including dissections, are one of the potential major complications that may occur during transarterial oncologic embolizations. An arterial dissection may lead to end organ ischemia or make delivery of the embolic treatment impossible. The natural history of these injuries and the ability of patients to successfully undergo subsequent treatment are not well established [9–11]. The purpose of our study is to identify the incidence and outcome of iatrogenic visceral artery dissections during transarterial therapy of liver tumors.

✉ Erica S. Alexander
Erica.s.alexander@gmail.com

¹ Department of Interventional Radiology, Hospital of the University of Pennsylvania, 3400 Spruce Street, 1 Founders-MRI Education Center, Philadelphia, PA 19104, USA

Materials and methods

Institutional review board approval was obtained for this single-center retrospective study. Our institution's quality assessment (QA) database (HI-IQ, ConexSys, Lincoln, RI) was used to identify all patients with liver tumors, including primary and metastatic lesions, who underwent transarterial hepatic embolization therapies or pre-TARE scintigraphic mapping by our institution's interventional radiology department from January 2001 to July 2017. The procedures were performed by one of the ten fellowship trained and board certified interventional radiologists with between 2 and 35 years of experience. Transarterial therapies were performed as previously described [12–15].

The QA database was searched for, “intimal injury/dissection,” associated with TACE, TAE, TARE, and pre-TARE scintigraphic mapping. Patient data and procedure information were obtained from the institution's electronic medical record and picture archiving and communication system.

In cases where iatrogenic arterial dissection was identified as a complication, the medical record was evaluated to assess if the dissection was categorized as flow-limiting, defined as an occluded vessel without antegrade flow, by the operating physician. Additionally, the type of catheter and/or wire used at the time the dissection was identified, the artery in which the dissection occurred, if and how the dissection was treated, if the intended procedure was successfully completed either on the day of the scheduled treatment or on a subsequent date, and the patency of the affected artery on follow-up imaging (arteriography, triphasic liver CT, and CT angiography with arterial phase imaging). Artery patency after dissection was graded as follows: complete resolution of the dissection, near complete resolution (< 30% arterial stenosis), unchanged appearance of a non-flow-limiting dissection, progressive luminal narrowing, and complete occlusion. Patient demographic information, including tumor histology, presence of variant anatomy, receipt of liver transplant, and receipt of prior transarterial liver-directed therapies, was also collected.

Over the 16-year review period, 2253 patients were treated with transarterial hepatic therapies for oncologic treatment and underwent a total of 3776 procedures (3013 TACE; 711 TARE and pre-TARE; 52 TAE). Thirty-nine patients were affected by dissection; 24 were men and 15 were women, with an average age of 58 ± 13 years (mean \pm SD). The most common tumor histology was hepatocellular carcinoma (21/39). Metastatic lesions included colon cancer (6/39), neuroendocrine carcinoma (5/39), cholangiocarcinoma (3/39), esophageal carcinoma (2/39), appendiceal carcinoma (1/39), and gastric

carcinoma (1/39). Two of the 39 patients had undergone an orthotopic liver transplant, one patient had undergone a right hepatic lobectomy, and 15 patients had undergone previous transarterial oncologic therapy prior to the recorded dissection. Arterial anatomy and presence of variants are summarized in Table 1.

Results

Forty of 3776 procedures (1.1%) were associated with iatrogenic dissections of the visceral vasculature, affecting 39 patients (Fig. 1). When available, the catheter and wire used at the time of dissection were noted (Table 2). The location of the dissection, in the 39 affected procedures, is summarized in Table 3.

Thirteen of the 40 dissections were deemed to be flow-limiting by the treating physician, resulting in complete or near complete occlusion (i.e., < 30% residual lumen) of the affected artery. Ten of the 40 dissections (6 flow-limiting, 4 non-flow limiting) were treated intra-procedurally. Treatment approach and outcome are summarized in Fig. 2.

Of the 40 dissections that occurred, 68% (27/40) of cases were successfully completed with delivery of the intended embolic therapy on the same day; four of these completed cases occurred in the setting of a flow-limiting dissection. Of the 13 cases that were aborted, eight were successfully completed at a later date. The outcomes of the remaining 5 cases were as follows: three patients were lost to follow-up, one dissection was noted to be completely resolved on follow-up imaging, and one dissected artery demonstrated unchanged partial occlusion on follow-up. The patient who had complete resolution of his dissection chose to proceed with Sorafenib for treatment of his hepatocellular carcinoma. The patient with unchanged partial occlusion went on to receive radiation therapy of the liver.

Follow-up imaging was obtained in 26 of the 40 cases at a median time of 63 days (range 13–976 days). Arteriography,

Table 1 Arterial anatomy of patients affected by iatrogenic dissection

Arterial anatomy	<i>n</i> (total = 39 patients)
Classic celiac anatomy	19
Replaced left hepatic artery	10
Replaced right hepatic artery	5
Transplant common hepatic artery anastomosed to the superior mesenteric artery	1
Trifurcating common hepatic artery	1
Right hepatic artery originating from aorta	1
Pre-existing high-grade celiac stenosis	1
Two left hepatic arteries	1

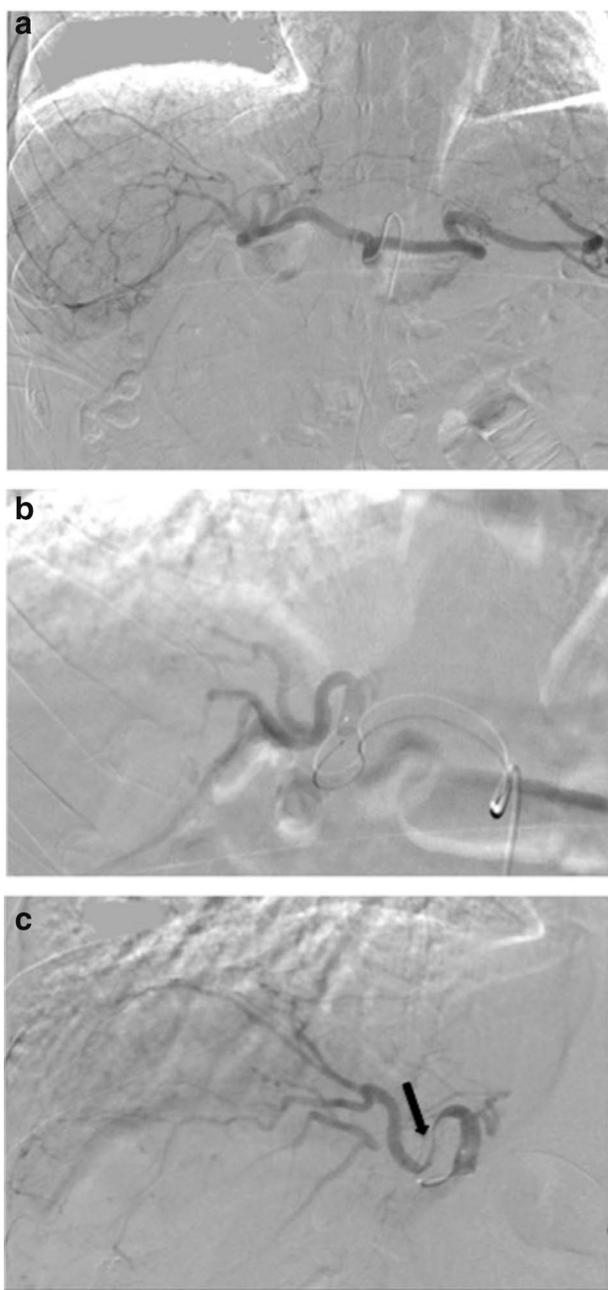


Fig. 1 A 67-year-old male with hepatocellular carcinoma, with tumor burden predominately in the right hepatic lobe undergoing TACE. **a** Arteriography reveals classic celiac artery anatomy, along with a hypervascular tumor supplied by the right hepatic artery in segments 6/7. **b** Microcatheter is seen within the right hepatic artery. **c** Arteriography of the right hepatic artery reveals a focal, non-flow-limiting dissection (arrow)

associated with subsequent intra-arterial hepatic tumor therapy, was performed in 77% of patients (20/26); triphasic liver CT was obtained in 15% of patients (4/26); and CT angiography with arterial phase imaging was obtained in 8% of patients (2/26). Appearances of the dissected artery,

as described in follow-up imaging reports, are described (Table 4).

Discussion

Iatrogenic celiac axis and hepatic artery dissections occur rarely during transarterial hepatic tumor embolization and embolization planning. In this study, iatrogenic injuries occurred in 1.1% of cases, a rate similar to that reported previously in literature [7, 9, 10]. Additionally, the majority of procedures could be successfully completed despite the presence of iatrogenic dissections. On the date of injury, 68% of cases were successfully completed, and an additional 20% of cases were completed during a follow-up appointment. This yielded a total technically successful treatment rate of 88% in cases associated with iatrogenic dissections. According to The Society of Interventional Radiology's Standards of Practice Committee, the threshold for iatrogenic dissections preventing treatment should be less than 1% [16]. In this series, only 0.1% of transarterial treatments that were complicated by iatrogenic dissections did not go on to receive further intra-arterial treatment at our institution. However, given that over half of these dissections occurred in patients who were lost to follow-up, this number may be an overestimate.

Iatrogenic arterial dissections during transarterial oncologic procedures are caused by direct trauma from the guidewire, catheter tip, and/or jet of contrast injection [10].

It is theorized that injury rates may be increased in the setting of tortuous anatomy associated with congenital anatomic variations, which require extensive catheter manipulation [11, 17]. In this series, about half (51%) of the 39 patients with dissections had anomalous arterial anatomy. Other studies have identified Child–Pugh score, cumulative dose of chemotherapeutic agents, and technical difficulties during treatment, as potential risk factors for arterial damage [10, 18]. Over a third of the patients in our series (15/39) had undergone prior transarterial oncologic therapy; this may alter the integrity of the arteries, making them more prone to injury. It is theorized that surgery affecting the liver or hepatic arteries (transplant or hepatectomy) may predispose patients to dissection secondary to stricturing or scarring. However, given the small size of this study and the even smaller proportion of patients underwent prior transplant or hepatectomy, this study was underpowered to test that hypothesis.

In our series, immediate attempt to treat the dissection was made in 25% (10/40) of the cases. Treatments were varied and were based on operator preference; they included intra-arterial nitroglycerin, intra-arterial or intra-venous heparin, percutaneous angioplasty, and combinations of the aforementioned therapies. Of the treated cases, 40% (4/10)

Table 2 Catheter and/or wire used at the time of iatrogenic dissection

Catheter and/or wire	n (total = 40 procedures)
3F microcatheter and 0.018F microwire	24
Cobra 1 (Merit OEM, Salt Lake City, UT) and 0.035F Glidewire	2
4F RIM(Merit OEM, Salt Lake City, UT)	1
5.5F Rosch catheter (Cook Medical, Bloomington, IN)	1
Cobra 1 (Merit OEM, Salt Lake City, UT) and Bentson wire (Cook Medical, Bloomington, IN)	1
Simmons (Merit OEM, Salt Lake City, UT) and 0.035F Glidewire	1
Surefire infusion system (TriSalus Life Sciences, Denver, CO)	1
Tracker 325 microcatheter (Boston Scientific, Marlborough, MA)	1
Unknown	8

Table 3 Site of arterial dissections associated with transarterial liver-directed therapies

Dissection location	n
Common hepatic artery	11
Right hepatic artery	7
Left hepatic artery	6
Left gastric artery	6
Celiac artery	5
Proper hepatic artery	3
Superior mesenteric artery	1

of therapies were completed on the same day. Yoon et al. treated 4 patients who experienced severe arterial stenosis with balloon angioplasty; two were lost to follow-up. Of the patients for whom follow-up was available, one patient was treated with a 5-mm balloon 28 days after celiac artery dissection; however, no improvement was seen. The other patient was treated with a 3-mm balloon 36 days after dissection of the left hepatic artery, and arterial recanalization was seen [10]. Due to the variance in therapies and the small

percentage of patients who underwent treatment, it is difficult to generalize the efficacy of these therapies.

A limitation of our retrospective study includes the potential for reporting bias. The dissections included in this study are those that were self-reported by the operators and documented in our institution’s QA database. Non-flow-limiting dissections or dissections that did not interfere with treatment administration may have been underreported. Oftentimes, the presence of a dissection was described in the imaging report and/or database; however, corresponding images were not saved to the PACs imaging system. As a result, imaging confirmation could not be verified by the study investigators. There were many interventional radiologists represented in this sixteen-year treatment cohort; this allowed for variation in treatment technique, including types of catheters used and the timing of angiographic runs. This in turn may have impacted the probability of causing a dissection and detecting one, should they occur. Additionally, the choice of continuing treatment after identification of a dissection was up to the operating physician. Also, the low

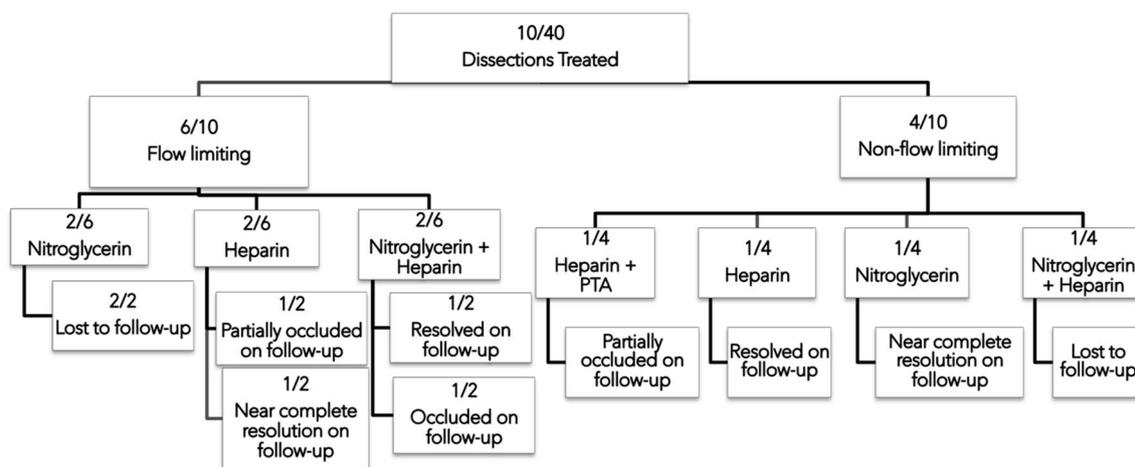


Fig. 2 Flowchart of the treated iatrogenic dissections, with treatment approach and subsequent appearance of the artery

Table 4 Outcome of arterial dissection noted on follow-up imaging reports (arteriography, triphasic liver CT, and CT angiography with arterial phase imaging)

Follow-up imaging (26/40 cases)	<i>n</i>	%
Complete resolution	15/26	58
Near complete resolution (<30% stenosis)	3/26	12
Unchanged appearance of non-flow-limiting dissection	4/26	15
Progression of luminal narrowing	3/26	12
Complete occlusion	1/26	4

incidence of dissection and the variation in treatment therapies make it impossible to extrapolate how best to manage this rare complication.

Conclusions

The incidence of iatrogenic dissection of the celiac axis or hepatic artery during transarterial hepatic tumor embolization is low. Our findings suggest that most patients who sustain iatrogenic dissection can still undergo successful treatment and that the majority of injuries do not result in long-term occlusion.

Compliance with ethical standards

Conflict of interest Erica Alexander declares that she has no conflicts of interest. Gregory Nadolski receives research support from Guerbet LCC and Teleflex. Michael Soulen receives research support from Guerbet LCC and BTG International, is a consultant for Guerbet LCC and Genentech, and is a proctor for Sirtex. S. William Stavropoulos is a consultant for Becton–Dickinson and receives research support from Cook and Sillajen. Stephen Hunt is a consultant for BTG and receives research grants from BTG, SIO, SIR, and RSNA. Terence Gade is a consultant for Trisalut and received an investigator initiation grant from Guerbet LLC. Max Itkin has no related conflicts to declare. Susan Shamimi-Noori is a proctor for Sirtex.

References

- Kwan SW, Kerlan RK, Jr., Sunshine JH (2010) Utilization of interventional oncology treatments in the United States. *J Vasc Interv Radiol* 21 (7):1054–1060. <https://doi.org/10.1016/j.jvir.2010.02.028>
- Sun JY, Yin T, Zhang XY, Lu XJ (2019) Therapeutic advances for patients with intermediate hepatocellular carcinoma. *J Cell Physiol* 234 (8):12116–12121. <https://doi.org/10.1002/jcp.28019>
- Kouri BE (2018) Interventional Oncology: Optimizing Transarterial Therapies for the Treatment of Hepatic Malignancy. *Tech Vasc Interv Radiol* 21 (4):205–222. <https://doi.org/10.1053/j.tvir.2018.07.002>
- Ma J, Gimenez JM, Sandow T, Devun D, Kirsch D, Gulotta P, Gilbert P, Kay D (2017) Intraarterial Liver-Directed Therapies: The Role of Interventional Oncology. *Ochsner J* 17 (4):412–416
- Berger DH, Carrasco CH, Hohn DC, Curley SA (1995) Hepatic artery chemoembolization or embolization for primary and metastatic liver tumors: post-treatment management and complications. *J Surg Oncol* 60 (2):116–121
- Tu J, Jia Z, Ying X, Zhang D, Li S, Tian F, Jiang G (2016) The incidence and outcome of major complication following conventional TAE/TACE for hepatocellular carcinoma. *Medicine (Baltimore)* 95 (49):e5606. <https://doi.org/10.1097/md.0000000000005606>
- Sakamoto I, Aso N, Nagaoki K, Matsuoka Y, Uetani M, Ashizawa K, Iwanaga S, Mori M, Morikawa M, Fukuda T, Hayashi K, Matsunaga N (1998) Complications associated with transcatheter arterial embolization for hepatic tumors. *Radiographics* 18 (3):605–619. <https://doi.org/10.1148/radiographics.18.3.9599386>
- Peterson JL, Vallow LA, Johnson DW, Heckman MG, Diehl NN, Smith AA, Tzou KS, Paz-Fumagalli R, Kim S, Ko SJ, Daugherty LC, Kim GP, Brown N, Mori KW, Buskirk SJ (2013) Complications after 90Y microsphere radioembolization for unresectable hepatic tumors: An evaluation of 112 patients. *Brachytherapy* 12 (6):573–579. <https://doi.org/10.1016/j.brachy.2013.05.008>
- Onizuka H, Sueyoshi E, Ishimaru H, Sakamoto I, Uetani M (2017) Arterial injury during transcatheter arterial chemoembolization for hepatocellular carcinoma: predictors of risk and outcome. *Abdom Radiol (NY)* 42 (10):2544–2550. <https://doi.org/10.1007/s00261-017-1168-6>
- Yoon DY, Park JH, Chung JW, Han JK, Han MC (1995) Iatrogenic dissection of the celiac artery and its branches during transcatheter arterial embolization for hepatocellular carcinoma: outcome in 40 patients. *Cardiovasc Intervent Radiol* 18 (1):16–19
- Jung E, Shin JH, Kim JH, Yoon HK, Ko GY, Sung KB (2017) Arterial dissections during transcatheter arterial chemoembolization for hepatocellular carcinoma: a 19-year clinical experience at a single medical institution. *Acta Radiol* 58 (7):842–848. <https://doi.org/10.1177/0284185116676654>
- Gee M, Soulen MC (2002) Chemoembolization for hepatic metastases. *Tech Vasc Interv Radiol* 5 (3):132–140. <https://doi.org/10.1053/tvir.2002.36422>
- Chao C, Stavropoulos SW, Mondschein JI, Dagli M, Sudheendra D, Nadolski G, Soulen MC (2017) Effect of Substituting 50% Isovue for Sterile Water as the Delivery Medium for SIR-Spheres: Improved Dose Delivery and Decreased Incidence of Stasis. *Clin Nucl Med* 42 (3):176–179. <https://doi.org/10.1097/rlu.0000000000001532>
- de Baere T, Arai Y, Lencioni R, Geschwind JF, Rilling W, Salem R, Matsui O, Soulen MC (2016) Treatment of Liver Tumors with Lipiodol TACE: Technical Recommendations from Experts Opinion. *Cardiovasc Intervent Radiol* 39 (3):334–343. <https://doi.org/10.1007/s00270-015-1208-y>
- Ruutiaainen AT, Soulen MC, Tuite CM, Clark TW, Mondschein JI, Stavropoulos SW, Trerotola SO (2007) Chemoembolization and bland embolization of neuroendocrine tumor metastases to the liver. *J Vasc Interv Radiol* 18 (7):847–855. <https://doi.org/10.1016/j.jvir.2007.04.018>
- Brown DB, Nikolic B, Covey AM, Nutting CW, Saad WE, Salem R, Sofocleous CT, Sze DY, Society of Interventional Radiology Standards of Practice C (2012) Quality improvement guidelines for transhepatic arterial chemoembolization, embolization, and chemotherapeutic infusion for hepatic malignancy. *J Vasc Interv Radiol* 23 (3):287–294. <https://doi.org/10.1016/j.jvir.2011.11.029>
- Clark TW (2006) Complications of hepatic chemoembolization. *Semin Intervent Radiol* 23 (2):119–125. <https://doi.org/10.1055/s-2006-941442>

18. Maeda N, Osuga K, Mikami K, Higashihara H, Onishi H, Nakaya Y, Tatsumi M, Hori M, Kim T, Tomoda K, Nakamura H (2008) Angiographic evaluation of hepatic arterial damage after transarterial chemoembolization for hepatocellular carcinoma. *Radiat Med* 26 (4):206-212. <https://doi.org/10.1007/s11604-007-0216-5>

Publisher's Note Springer Nature remains neutral with regard to jurisdictional claims in published maps and institutional affiliations.