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Physics

Technique for the administration of high-dose-rate brachytherapy to the bile duct using a nasobiliary catheter

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ABSTRACT

PURPOSE: Cholangiocarcinoma patients who are potential candidates for liver transplantation may be treated with high-dose-rate (HDR) brachytherapy using a minimally invasive nasobiliary catheter in an effort to escalate the radiotherapy dose to the tumor and maximize local control rates. This work describes the equipment, procedures, and quality assurance (QA) that enables successful administration.

METHODS AND MATERIALS: This work describes the nasobiliary catheter placement, simulation, treatment planning, treatment delivery, and QA. In addition, a chart review was performed of all patients who received endoscopic retrograde cholangiopancreatography for HDR bile duct brachytherapy at our institution from 2007 to 2017. The review evaluated how many patients were treated and the number of patients who could not be treated because of anatomic and/or equipment limitations.

RESULTS: From 2007 to 2017, 122 cholangiocarcinoma patients have been treated with HDR brachytherapy using a nasobiliary catheter. Three patients underwent catheter placement but did not receive brachytherapy treatment due to catheter migration between placement and treatment or because the HDR afterloader was unable to extend the source wire into the treatment site. Periodic QA is recommended for ensuring whether the HDR afterloader is capable of extending the source wire through an extensive and curved path.

CONCLUSIONS: Intraluminal HDR brachytherapy with a nasobiliary catheter can be successfully administered. Procedures and QA are described for ensuring safety and overcoming technical challenges.

Keywords: Bile duct; High-dose-rate; Nasobiliary; ERCP; Intraluminal brachytherapy

Introduction

Patients with unresectable perihilar cholangiocarcinoma have been successfully treated with neoadjuvant chemoradiotherapy followed by liver transplantation (1). This approach results in a 5-year survival rate of approximately 50% in patients who otherwise would have no potentially curative therapy option (2). The chemoradiotherapy regimen may include brachytherapy to escalate the radiotherapy dose and maximize local control (3).

Brachytherapy may be administered transhepatically using a percutaneous biliary drainage catheter or through a nasobiliary catheter (4–11). For patients who are potential candidates for liver transplantation, the nasobiliary approach is preferred due to the risk of tumor seeding and other invasive procedure risks associated with the transhepatic approach (12). Although the nasobiliary approach is minimally invasive, the catheter path is extensive and curved, which causes the high-dose-rate (HDR) delivery to be technically challenging.

A study on the feasibility and safety of HDR biliary brachytherapy using a nasobiliary approach from our institution demonstrated that HDR brachytherapy technique resulted in fewer catheter migration events and lower complication rates compared with low-dose-rate brachytherapy (13). The

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aim of this study was to communicate the technical aspects of HDR simulation, treatment planning, delivery, and quality assurance (QA) for nasobiliary brachytherapy treatments.

Methods and materials

Treatment outcomes

A chart review was performed of all patients who received endoscopic retrograde cholangiopancreatography (ERCP) for HDR bile duct brachytherapy at our institution between August 2007 and December 2017. The review evaluated how many patients were treated and how many could not be treated due to anatomic and/or equipment limitations. This study was approved by our institutional review board.

Treatment procedures

The treatment procedure includes pretreatment QA, catheter placement, simulation, treatment planning, and treatment delivery. A procedure workflow is illustrated in Fig. 1. The person(s) who perform the tasks in Fig. 1 is identified using color shading: endoscopist (orange), physicist (white), physician (light blue), and radiation therapy technologist or medical imaging technician (lavender). Table 1 provides a summary of relevant equipment.

Pretreatment QA

Periodic QA using a quasianatomical device has been used to test the afterloader's capability of traversing through the nasal, stomach, duodenum, and bile duct (14). The QA device ensures that the afterloader has not changed substantially after radioactive source exchange, and that the service engineer has tuned the device such that the radioactive source wire has slightly greater capability to extend than the nonradioactive "dummy" wire. This helps to avoid a situation in which the dummy wire can reach the treatment position, whereas the active source cannot, thereby preventing the accumulation of unnecessary transit dose (14). The device also ensures that each new lot of 4.7-Fr intraluminal catheters performs similarly to previous lots. Finally, the device may be used to characterize typical transit doses delivered by the source wire.

A dry lubrication of the afterloader wire is performed according to the vendor recommendations before each patient treatment to decrease friction between the source wire and the 4.7-Fr catheter. The dry lubrication transfers a small amount of polytetrafluoroethylene (also known as PTFE or Teflon) from the catheter onto the dummy and source wires, decreasing the friction between the source wire and the catheter. The dry lubrication consists of repeatedly administering (e.g., 10 times) a test plan, including dummy and radioactive wire extensions, to the distal end of a 150.0 cm long 4.7-Fr catheter.

Treatment catheter placement

Brachytherapy catheter placement has been described by Mukewar et al (13). An ERCP technique is used to place an 8.5- or 10-Fr 250 cm long nasobiliary catheter (#ENDB-8.5

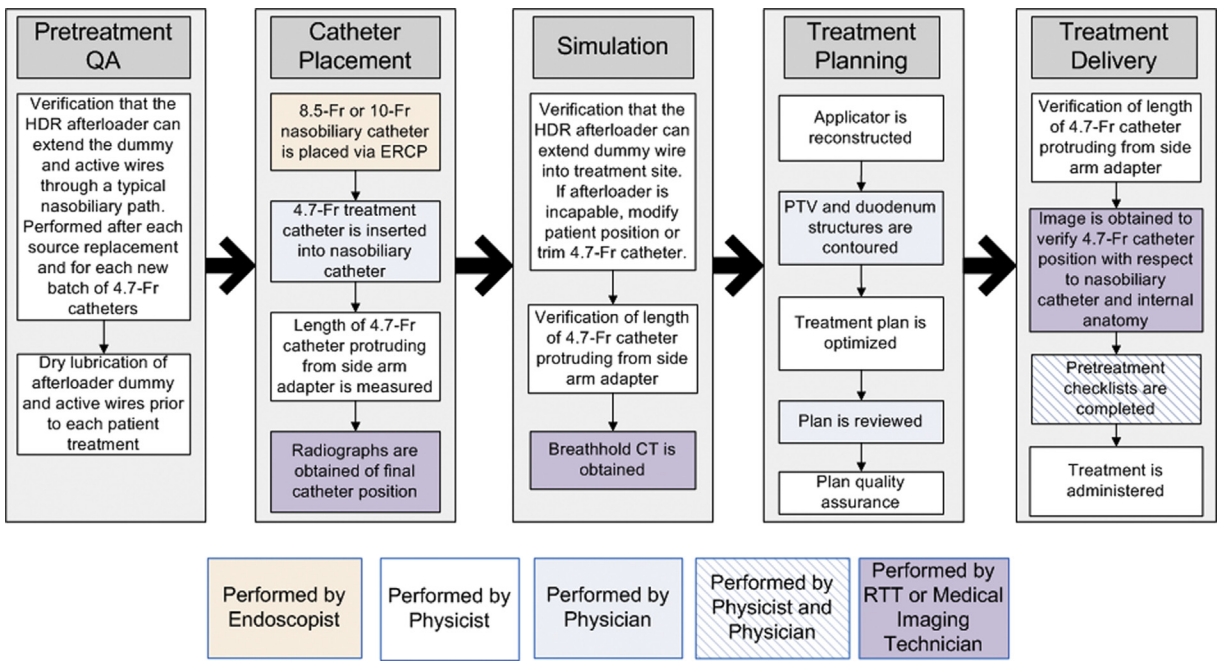

Fig. 1. Nasobiliary workflow diagram. Pretreatment quality assurance (QA), catheter placement, simulation, treatment planning, and treatment delivery steps are outlined. The tasks performed by the endoscopist, physicist, physician, and radiation therapy technologist or medical imaging technician are delineated with shading. ERCP = endoscopic retrograde cholangiopancreatography; HDR = high-dose-rate; PTV = planning target volume. (For interpretation of the references to color in this figure legend, the reader is referred to the Web version of this article.)