A coaxial catheter system for afterloading radioactive sources for the interstitial irradiation of brain tumors

Technical note

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A coaxial two-catheter system that facilitates accurate stereotaxic placement of radioactive sources for the interstitial irradiation of brain tumors is described.

KEY WORDS • brain tumor • interstitial irradiation • stereotaxic surgery • catheter implant system

INTERSTITIAL irradiation is a promising technique for the local treatment of brain tumors. However, for successful treatment of rapidly expanding (malignant) brain tumors, the dose rate of radiation delivered from stereotaxically implanted sources must be sufficiently high that tumor cells receive a critical threshold dose during a complete cell cycle. This condition can be met by using as radioactive sources high-activity radioisotopes that can be removed from the brain after the dose is delivered; if the sources remain implanted, normal brain surrounding the source will be exposed to potentially toxic doses of radiation. Radioactive sources that are encased in catheters can be removed after the desired dose is delivered; moreover, catheters can hold the source with precision at the tumor target site in the often semisolid or liquid centers of more grossly necrotic malignant brain tumors.

A catheter system for interstitial irradiation of brain tumors should have a stylet that will hold the catheter completely rigid during stereotaxic placement, and have no "memory" for bending after the stylet has been removed. In addition, the position of the catheter should be verifiable before radioactive sources are afterloaded. We have designed and fashioned such a system, and have used it for the implantation of high-activity iodine-125 ($^{125}$I) sources into 20 patients harboring primary and metastatic brain tumors.

Description of the Catheter

The catheter system (Fig. 1) consists of two coaxial 50-durometer clear silicone tubes with closed tips. The outer catheter is 1.57 mm in inside diameter and 2.16 mm in outside diameter. It is fitted with an adjustable silicone base reinforced with Dacron mesh. The base is 1 mm thick with a diameter of 15 mm, and has a tubular collar that allows fixation at the burr hole of both outer and inner catheters. The inner catheter is 1.04 mm in inside diameter and 1.47 mm in outside diameter, and contains the radioactive source.

For insertion, the patient is given local anesthesia. The outer catheter is filled with a metal stylet to make it rigid over its length, and is inserted stereotaxically through a burr hole in the tumor target using a Leksell stereotaxic frame modified for use with a computerized tomographic (CT) scanner. The outer catheter is held in position at the burr hole by the base, and the stylet is removed. The inner catheter containing non-radioactive (dummy) sources is inserted, after which, intraoperative radiographs are taken to confirm the position of the dummy sources. (The catheter is not radiopaque, and only the dummy sources can be

Fig. 1. The catheter system consists of the outer catheter (upper), shown with its adjustable Dacron-reinforced silicone base and metal stylet for stereotaxis, and the coaxial inner catheter (lower), containing two radioactive sources.
Catheter system for interstitial irradiation

Fig. 2. Radiograph with the stereotaxic frame in position showing deviation from the target of one of two polyethylene catheters housing high-activity iodine-125 sources. The catheter bent when it encountered tough gliotic white matter around the tumor, which was a right parietal glioblastoma. This problem has been eliminated in the coaxial catheter system.

visualized radiographically.) When it is certain that the dummy seeds are correctly placed, the inner catheter and dummy sources are removed and replaced with an identical catheter containing the radioactive source(s). Because of the relatively high coefficient of friction of silicone, a small amount of mineral oil is used to lubricate the inner catheter. A medium-sized Weck hemoclip* fixes the inner catheter to the base of the outer catheter at the burr hole. The base is then sutured to the pericranium, and the wound is closed to internalize the entire system.

A CT scan and orthogonal skull radiographs are taken the next day to assure that the seeds are in the correct position, after which the dosimetry can be calculated. After the calculated dose has been delivered to the tumor, catheters are removed under local anesthesia.

Discussion

During the early phases of our ongoing clinical trial of removable implantation of gold-198 (198Au) and 125I sources for the interstitial brachytherapy of brain tumors, we used a simple polyethylene tube to position the radioactive sources. This device was unacceptable; sources filled the distal end of the catheter and the stylet could pass to within only 1 to 2 cm of the tip, and could not hold the tip of the catheter rigid. As the stylet was stereotaxically guided to the tumor target, the (often gliotic) interposed brain bent the pliable catheter tip. This problem was exacerbated because polyethylene acquires a “memory” for bends during autoclave heating, and catheters were frequently placed inaccurately (Fig. 2). Because of intraoperative adjustments necessary to reposition sources, surgeons and other operating room personnel were exposed to levels of radiation that were higher than necessary.

The system described here eliminates these problems. The silicone material used to fashion these catheters is biologically inert and has no “memory” for bends. Because the stylet can be placed all the way to the unoccupied tip of the outer catheter, accurate stereotaxic positioning of the catheter can be achieved (Fig. 3). The sources, housed in the inner catheter, are removed from their lead shielding and loaded only after the catheter has been positioned.

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References


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