ELECTROCAUTERY-INDUCED IGNITION OF SPARK SHOWERS AND SELF-SUSTAINED COMBUSTION OF ONYX ETHYLENE-VINYL ALCOHOL COPOLYMER

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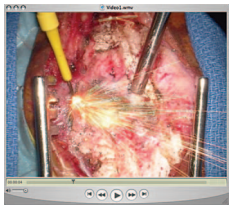
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ONLINE DIGITAL VIDEO



OBJECTIVE: Ethylene-vinyl alcohol copolymer mixed with micronized tantalum (Ta) as radiopacifier (Onyx; Micro Therapeutics Inc., Irvine, CA) has emerged as a useful liquid embolic agent for vascular malformations. We describe intraoperative ignition of Onyx-embolized tissue and undertake an in vitro investigation to reproduce and characterize this hazard.

METHODS: Samples of Onyx, Ta-depleted Onyx, Ta–*n*-butylcyanoacrylate (Ta-NBCA), and Ta powder were exposed to monopolar and bipolar electrocautery in cut and coagulation modes at different power settings to reproduce the intraoperative findings. Recordings of sparking and combustion events were analyzed to characterize duration and relative frequency.

RESULTS: Spark showers and self-sustained combustion were observed intraoperatively when an Onyx-embolized artery was coagulated with the monopolar electrocautery. Sparking covered a radius greater than 10 cm, and combustion lasted a median of 1.65 seconds (range, 0.3–12.3 s). Sparking and sustained combustion were reproduced in vitro by both cut and coagulation monopolar modes in Onyx casts and free Ta powder but not in samples of Ta-depleted Onyx or casts of Ta-NBCA. Ignition was similarly observed when using bipolar electrocautery but only at higher energy settings.

CONCLUSION: Electrocautery use on tissue containing Onyx results in potentially dangerous uncontrolled sparking and combustion in a process that is Ta dependent. It is recommended that Ta-NBCA be used instead of Onyx in situations mandating the use of a liquid embolic and high-energy electrocautery, pending the development of a safer radiopacifier for use with ethylene-vinyl alcohol copolymer.

KEY WORDS: Combustion, Complications, Surgical safety, Tissue injury

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Ethylene-vinyl alcohol copolymer (EVOH) (Onyx; Micro Therapeutics Inc., Irvine, CA) has emerged as a useful liquid embolic agent for the endovascular embolization of cerebral arteriovenous malformations (AVM) (2, 6, 8). Onyx consists of EVOH dissolved in dimethyl sulfoxide (DMSO) and micronized tantalum (Ta) powder to provide radiopacity. Initial concerns regarding the toxicity of its solvent, DMSO (4), have not limited its clinical use, and the associated rate of complications has been favorable (3, 12). In contrast to *n*-butylcyanoacrylate (NBCA), Onyx has the advantage of being cohesive and nonadhesive, thereby enabling a slow, controlled embolization process, with a consequent higher rate of angiographic occlusion and a decreased incidence of injury to the vascular wall (8, 9). The spongy consistency of Onyx-embolized vascular malformations provides better tissue-handling characteristics and keeps the nidus elastic and deformable, in stark contrast to NBCA (1). This property enables an easier dissection from the surrounding brain tissue by microsurgical technique during intracranial resection (5). Like others in the field, we have found Onyx to be a useful agent with attractive liquid embolic properties (9). We report an alarming and unexpected flammability and safety hazard of Onyx (Ta-EVOH) in its current form when used in conjunction with the monopolar electrocautery in the operating room. The flammability

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hazard was first noted during craniotomy for surgical exposure and resection of a combined pial–dural arteriovenous fistula, during which we encountered ignition of Onyx-embolized arterial feeders with production of spark showers and self-sustained combustion of the Onyx casts when coming into contact with the monopolar electrocautery. Here, we describe the temporal dynamics of this phenomenon, replicate it in the laboratory setting, characterize its dependence on electrocautery power settings, and identify the radiopacifier Ta as a major combustible substance within the Onyx cast.

PATIENTS AND METHODS

Operative Material

A 31-year-old patient initially presented with an intracranial hemorrhage from a left parieto-occipital combined dural and pial arteriovenous fistula, for which he underwent transarterial embolization of two major feeders emanating from the left occipital artery and a feeder off of the posterior branch of the middle meningeal artery. Onyx embolic agent was used according to the manufacturer's instructions (*Fig. 1*). On the next day, the patient underwent a left parieto-occipital craniotomy through a linear incision to disconnect the fistula, which had persistent cortical venous drainage to the vein of Trolard. A standard monopolar radiofrequency (RF) electrocautery unit (Model Sabre 2400; Conmed Corp., Utica, NY) was used with a standard pen-type tip. The monopolar RF electrocautery unit was used on standard settings for coagulation at an energy level of 35 W. A bipolar electrocautery (Synergy Malis Precision Bipolar Coagulator Model No. 80-1187; Codman & Shurtleff Inc., Raynham, MA) was used at a level of 35 Malis units with a standard 1-mm-wide bayonet tip. Intraoperative recording was made in digital format through the stereoscopic operating microscope (Leica OH3, Wetzlar, Germany) with a digital recording unit (DRS2 Digital Recording System; Med X Change, Inc., Bradenton, FL) and stored using MPEG-4 video compression at 30 frames per second on digital video disc media.

Preparation of Ta-rich and Ta-depleted Onyx Samples

A commercial preparation of Onyx 34 (Micro Therapeutics, Inc., Irvine, CA) was used for the initial experiment. Onyx 34 consists of 8% EVOH copolymer dissolved in 92% DMSO with micronized Ta powder (35% weight/volume) added for radiopacity. In the experiment with Ta-Onyx preparation, the Onyx 34 vial was shaken on a vibrating shaker (Vortex Genie; Micro Therapeutics, Inc.) for at least 20 minutes to enable complete suspension of the Ta microparticles as recommended by the manufacturer. In a separate set of experiments intended to exclude Ta as much as possible from the mixture, the Onyx 34 vial was stored upright to allow the Ta powder to settle for 4 hours. A sample of Ta-depleted Onyx supernatant, which was visibly free of Ta powder, was carefully withdrawn while avoiding shaking of the vial. Samples from both Ta-Onyx and Ta-depleted Onyx 34 were gently expressed from their respective syringes into a shallow bath filled with normal saline at a slow rate as recommended by the manufacturer. This resulted in approximately 2-cm-long cylindrical-shape casts (*Fig. 3*). Two hours were allowed for the DMSO solvent to diffuse into the bath and ensure permanent and coherent solidification of both Ta-Onyx and Ta-depleted Onyx samples prior to testing.

Preparation of the Ta Powder and the NBCA

A commercially available package of NBCA (Trufill Liquid Embolic System; Cordis-Johnson & Johnson, Miami Lakes, FL) containing Ta powder, NBCA liquid, and ethiodized oil was used for this part of the experiments. Ethiodized oil was mixed with NBCA in a 1:1 ratio under salt-free conditions and approximately 0.3 g of Ta powder was added to the mixture. Thorough mixing and triturating through a 19-gauge needle was performed to obtain uniform distribution of the components. The mixture was expressed slowly from a syringe into a normal saline solution where polymerization occurred, resulting in multiple small casts. Two hours were allowed for the NBCA samples to proceed to polymerization. A small

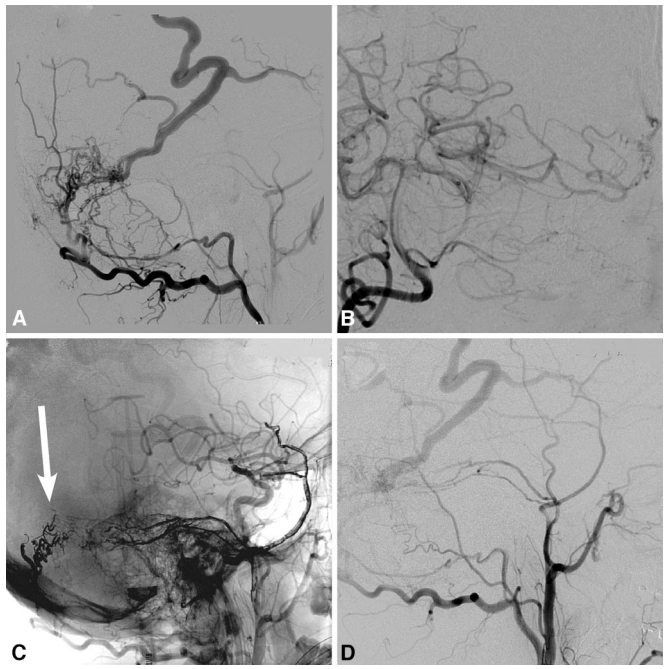


FIGURE 1. *Digital subtraction angiogram of a left external carotid artery injection (*A*, lateral) and of the right vertebral artery (*B*, anteroposterior) demonstrating, respectively, the dural and pial components of the combined pial–dural arteriovenous fistula with cortical venous drainage. Unsubtracted (*C*) and subtracted (*D*) lateral digital radiographs after embolization of the occipital artery feeders with ethylene-vinyl alcohol copolymer (Onyx) demonstrating the cast within the occipital artery branches and diminished but persistent flow through the fistula. The* arrow *(*C*) delineates the approximate location of the Onyx cast encountered during the initial dissection (*Fig. 2*).*

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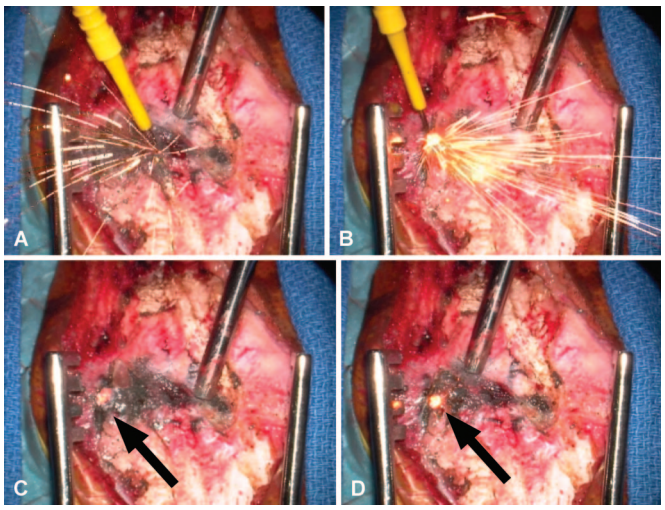


FIGURE 2. *Still images of two spark shower events* (A and B) *and two self-sustained combustion events of an Onyx cast* (C and D) (arrows) *during the subfascial dissection stage of the craniotomy. The location of the Onyx casts corresponds to the* arrow *in* Figure 1C. *Note the persistent combustion in panels* C and D *well after contact with the electrocautery tip has been interrupted* (C and D, *3 and 6 s, respectively, after the initiation of combustion and interruption of tip contact).*

heap of Ta powder (Trufill) was also tested separately for ignition and combustion (*Fig. 4*).

Response of Onyx Samples to Monopolar and Bipolar RF Electrocautery

The solidified Onyx containing Ta, Ta-depleted Onyx, Ta-NBCA samples, and Ta-powder were placed on a surgical towel moistened with normal saline, which was connected to the ground electrode pad. The RF electrocautery unit was used on standard settings for pure cut, blended cut, and coagulation at an energy level of 20 W, or pure cut at an energy level of 50 W. Bipolar cautery with energy settings at 15, 25, 35, 45, and 60 Malis units was applied using Malis bipolar forceps with a 1.0-mm tip (Malis Non-Stick Mirror Finish Bipolar Forceps Model No. 80-2993; Codman & Shurtleff Inc., Raynham, MA). The same microscope, video recording equipment, and analysis method were used to analyze the response of the samples to monopolar and bipolar stimulation.

Quantitative Video Analysis and Statistics

The video segments of the operative case and experiments were analyzed frame by frame using QuickTime software (Version 7.0; Apple Computer Inc.) on a Macintosh Quad G5 computer (Apple Computer Inc., Cupertino, CA). The duration of sparking showers and self-sustained combustion events was recorded. Two sparking events were considered distinct when separated by at least one frame that did not show sparks. The onset of the combustion event was defined as the frame in which the electrocautery tip ceased to be in contact with the specimen being analyzed. The end of the event was defined as the subsidence of the bright glow within the Onyx mass. Data analysis was carried out using JMP (Version 5.0; SAS Institute Inc., Cary, NC).

RESULTS

Ignition of Onyx-embolized Tissue by Monopolar Electrocautery

(see video at web site)

While using the monopolar electrocautery to dissect through the subcutaneous and fascial planes, we encountered unexpected sparking when the electrocautery tip made contact with the Onyx cast within the embolized occipital artery branch (*Fig. 2*). After closer inspection, two phenomena were uncovered: 1) the generation of a spark shower (*Fig. 2, A* and *B*), and 2) initiation of a self-sustained combustion of the Onyx cast, which persisted even after interrupting contact between the monopolar tip or halting monopolar current (*Fig. 2, C* and *D*). The sparking event analyzed showered to a radius greater than 10 cm. The self-sustained combusting core seemed in one instance to be migrating deeper into the transosseus portion of the embolized feeder artery without obvious interruption; the mean duration of identified sustained combustion events was 2.7 $\pm$ 3.1 seconds. During sustained combustion, pouring saline irrigation solution on the actively burning core did not immediately extinguish it; this suggests that an alternate source of oxygen is available, possibly from within the Onyx cast itself, to sustain combustion. No sparking or combustion events were encountered intraoperatively when using the bipolar electrocautery at normal settings on the same Onyx cast (35 Malis power units), which was as expected and consistent with the safety profile of Onyx during pial AVM resection. At this point, further use of monopolar electrocautery was avoided near the Onyx cast, and the procedure was completed successfully and without harm to the patient.

Characterization of Onyx Ignition by Monopolar Electrocautery

(see video at web site)

We next attempted to reproduce the intraoperative events in vitro. Standard casts of Onyx (*Fig. 3A*) were prepared and were found to readily ignite in contact with the monopolar electrocautery at an energy setting of 20 W. This ignition resulted in both spark showers (*Fig. 3B*) and self-sustained combustion (*Fig. 3C*). When the energy was increased to 50 W in cut mode, sparking was elicited even more easily, with only very light touch of the electrocautery tip to the Ta-Onyx cast. Next, the electrocautery was used in coagulation mode at 20 W and found to elicit both sparking and sustained combustion. The relative frequency of sparking and combustion for each experiment using Ta-Onyx is summarized in *Figure 3F*. There was a trend toward increased spark showers and decreased sustained combustion events with increased energy delivery, although this did not achieve statistical significance.

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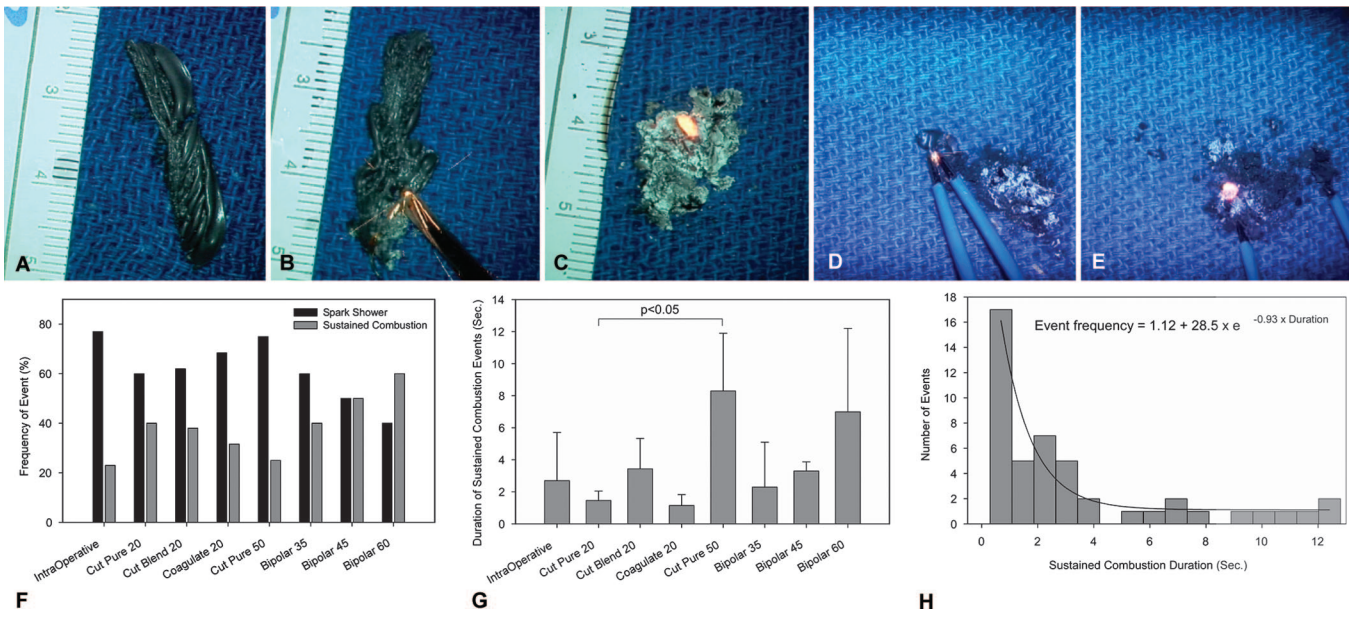


FIGURE 3. *A standard Ta-Onyx cast* (A) *can be ignited with the tip of the monopolar electrocautery to produce spark showers* (B) *and exhibit self-sustained combustion after withdrawal of the monopolar electrocautery* (C). *During self-sustained combustion, the Onyx cast generates sufficient heat to melt the edge of the plastic ruler* (C). *Higher-energy bipolar electrocautery causes similar sparking events* (D) *and self-sustained lava-like combustion* (E). F, *effect of monopolar and bipolar electrocautery energy setting on the relative frequency of spark showers and sustained combustion events.* G, *effect of monopolar and bipolar electrocautery energy settings on the duration of sustained combustion events.* H, *distribution of all recorded sustained combustion events modeled by a three-parameter exponential distribution* ($R^2 = 0.93$).

Saline irrigation of the self-combusting cast seemed to halt propagation of the burning front, but only after a slight delay.

Analysis of sustained combustion events of Ta-Onyx casts revealed an average duration of 2.8 ± 3.1 seconds, ranging between 0.4 and 12.3 seconds. Ignition towards combustion was achieved at 20 W regardless of the mode of monopolar electrocautery (*Fig. 3G*). The energy setting was found to influence the duration of sustained combustion events, with 50 W resulting in significantly longer-lasting combustion compared with 20 W in cut mode ($P < 0.05$) (*Fig. 3G*). The combustion events generated at 50 W were particularly intense, with a mean duration of 8.3 seconds, ranging from 5.4 to 12.3 seconds. The heat generated by the last combustion event was sufficiently intense to melt the nearby plastic ruler placed 4 mm away (*Fig. 3C*).

Energy-dependent Effect of Bipolar Electrocautery on Onyx

We tested the effect of bipolar electrocautery at energy settings between 15 and 60 Malis units on a number of standard Onyx casts. At less than 35 Malis units of deployed energy using the 1-mm bipolar tip, we were unable to elicit any spark showers or self-sustained combustion. At 35 Malis units, shrinkage and desiccation of the cast was initially noted and was followed by spark showers (*Fig. 3D*) and self-sustained combustion (*Fig. 3E*). The mean duration of the self-sustained combustion events observed with bipolar cautery energy settings between 35 and 60 Malis units was 3.7 ± 3.6 seconds, ranging from 0.5 to 11 seconds. In contrast to the trend described for monopolar electrocautery, increased energy settings led to more rapid onset of ignition, with a trend toward decreased sparking and increased combustion events (*Fig. 3F*). Higher energy settings caused a nonsignificant trend toward longer-lasting, sustained combustion events (*Fig. 3G*).

The duration of all recorded combustion events including intraoperative and in vitro were modeled by an exponential decay distribution using three parameters with a time constant of 0.93 seconds ($R^2 = 0.93$) (*Fig. 3H*).

Critical Role of Ta in Onyx Flammability (see video at web site)

We hypothesized that the radiopacifier Ta may be at least partially responsible for the flammability of Onyx; accordingly, we tested contact of electrocautery with Ta-depleted Onyx (*Fig. 4A*). The Ta-depleted preparation appeared white because of the precipitation of Ta out of the EVOH:DMSO solution. Despite trying various monopolar electrocautery settings, none could be found that would result in spark shower or combustion of Ta-depleted Onyx (*Fig. 4A*). Ta-NBCA casts were then tested for ignition by the monopolar electrocautery, but no spark showers or sustained combustion could be elicited, in stark contrast to Onyx (*Fig. 4B*). Ta powder was then tested independently of EVOH and NBCA (*Fig. 4, C–F*); it was found to be easily ignitable, and it exhibited sparking and sustained combustion in response to both monopolar (*Fig. 4, D* and *E*) and bipolar electrocautery (*Fig. 4F*). micronized Ta

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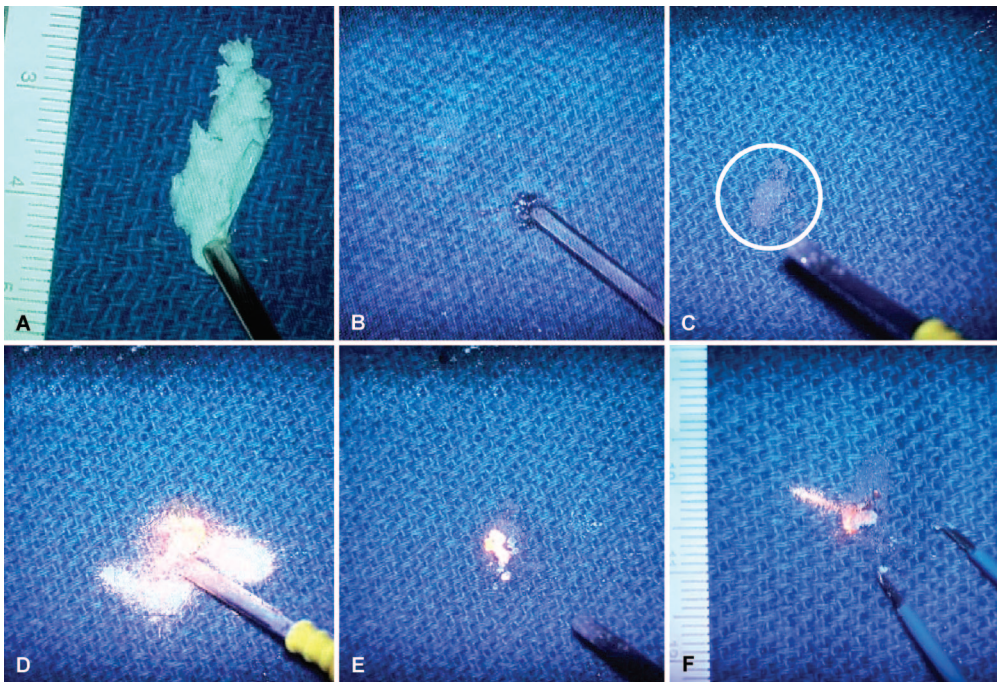


FIGURE 4. *Ta-depleted Onyx cast* (A) *is white in color because of the low Ta content and shows no sparking or combustion with monopolar electrocautery contact. In contrast to Onyx, monopolar electrocautery contact with a Ta-NBCA cast* (B) *at the same settings results in no spark or combustion despite multiple attempts. A heap of Ta powder* (C) *produces intense sparking when in contact with the monopolar electrocautery* (D) *followed by sustained combustion* (E). *Similarly, Ta powder shows sustained combustion after contact with bipolar electrocautery* (F).

added for radiopacity is in a state that makes it freely ignitable by monopolar electrocautery when used in Onyx, but not when added to NBCA.

DISCUSSION

To our knowledge, sparking and combustion of Onyx has not been previously reported in the literature. Resection of intracranial AVM previously embolized with Onyx is an established practice that has been safely performed without notable ignition or flammable complications. This is consistent with our intraoperative findings in the current case and others that bipolar electrocautery use around Onyx-embolized vessels at standard settings is not accompanied by ignition. It is serendipitous that our use of Onyx for preoperative embolization of the dural feeders to a combined pial–dural AVM led to intraoperative use of the monopolar electrocautery on Onyx-embolized tissue. Accordingly, this report is not intended to limit the use of Onyx for lesions that can be addressed wholly by using bipolar electrocautery but, rather, to highlight and characterize a troubling and potentially dangerous feature of Ta-EVOH when it comes in contact with monopolar electrocautery and, at least in vitro, with high-energy bipolar electrocautery. The current findings are likely to become more relevant as the superior liquid embolic characteristics of Ta-EVOH expand its indications for use to include preoperative embolization of peripheral vascular lesions and highly vascular spinal metastatic lesions (i.e., renal cell carcinoma), cases in which monopolar electrocautery is more commonly used during the surgical exposure.

Mechanisms of Tissue Injury by Sparking and Combustion of Onyx

The two phenomena observed in the operating room raise a serious concern for injury of surrounding tissue, especially any exposed neural structures or brain. The sparks generated by contact with the monopolar tip showered to a radius of more than 10 cm, with the potential for tissue contact burn from the landing sparks. Furthermore, the intense heat generated by the sustained combustion of Onyx may lead to direct thermal injury of surrounding tissue by both conduction and radiation as seen in *Figure 3C*. We also found that the duration of the sustained combustion was difficult to predict and that extinction with irrigation occurred only after a time delay. We can only speculate on the risk of a propagating front of self-sustained combustion acting like a fuse and leading to the deeper embolized nidus that may be hidden from surgical exposure. Although in our case the combustion did not seem to extend from the extracranial vessels to the intracranial nidus, the pattern of lava-like self-sustaining combustion witnessed is concerning.

Critical Role of Ta

The results of the experiments point to Ta as the source for the flammability of Onyx by monopolar and bipolar electrocautery. Ta is a metal that easily reacts with oxygen to Ta oxide at relatively low temperatures. Its flash point, the temperature at which spontaneous combustion occurs, is around 250°C (7). Based on testing, Ta powder is classified as hazardous material by the Commission of the European Union: "Combustible. Dry tantalum powder may spontaneously ignite on contact with air" (7). Flammability and self-sustained combustibility are clearly undesirable characteristics of an embolic material that may come in contact with sparks generated by electrocautery in the operating room. Interestingly, the presence of Ta in Ta-NBCA failed to provide it with spark generation and flammability, possibly because the Ta particles in polymerized Ta-NBCA are embedded in a compact cast

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without sufficient air to sustain a combustion reaction. In contrast, the sponge-like Onyx cast may maintain the Ta particles within proximity to microscopic air pockets, where they are able to recruit the oxygen necessary for ignition and the sustained combustion observed both intraoperatively and in vitro. Radiopacifying materials used in a clinical setting commonly incorporate one of the following elements: barium, bismuth, Ta, iodine, or zircon (10). Radiopacity of suitable elements depends on their atomic number, the absorption coefficient, and the wavelength of the x-rays used. Although in theory many more elements exhibit acceptable radiopaque properties, safety and availability considerations limit their practical use. Taki et al. (11) and Yamashita et al. (13) described an EVOH similar to Onyx, with metrizamide powder added as a contrast medium instead of Ta. The current findings should renew efforts to evaluate alternate radiopacifiers to enable the safe use of EVOH in the operating room in the hope of expanding its use and favorable properties as a liquid embolic agent to other vascular lesions involving the spine and peripheral tissues.

CONCLUSION

Ta added to the liquid embolic Onyx renders it highly ignitable by the monopolar electrocautery, intraoperatively leading to potentially injurious spark showers and prolonged self-sustained combustion. Surgeons intending to perform open surgery in the vicinity of Onyx casts should be aware of this unexpected and potentially hazardous characteristic. These findings make it unsafe to use the monopolar or higher-energy bipolar electrocautery on tissue that has been embolized with Ta-containing Onyx. Surgeons are urged to rely on low- to medium-energy bipolar electrocautery use near Onyx or to use Ta-NBCA as the liquid embolic of choice in situations that absolutely require the concomitant use of a liquid embolic agent and electrocautery. Given the superior embolic properties of Onyx, it is hoped that an alternate radiopacifier can be developed that can decrease the flammability of EVOH and facilitate its expanded use.

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COMMENTS

Schirmer et al. describe an experiment in which samples of Onyx (Microtherapeutics, Inc., Irvine, CA) were exposed to monopolar and bipolar electrocautery. The authors illustrate that spark showers and self-sustained combustion can occur intraoperatively when an Onyx-embolized artery is coagulated with monopolar cautery. This is extremely germane to the clinical model.

I have not yet personally operated on a patient who has been embolized with Onyx, but this is certainly a very important finding and consideration. A study such as this is quite intriguing and, I think, compels the industry to look very carefully at this embolic material when surgery is planned. I thank the authors for bringing this to the attention of the neurosurgical population. Obviously, the response from industry will be quite interesting as well.

Robert H. Rosenwasser
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The authors have recognized a potentially important complication associated with the surgical treatment of patients previously embolized with Onyx. After recognizing the combustion of Onyx-embolized tissue associated with the use of monopolar cautery in a patient, these investigators created an in vitro method for determining that tantalum powder, mixed with Onyx as a radiopacifier, is likely the combustible material. Interestingly, when tantalum (Ta) was mixed with n-butyl cyanoacrylate (NBCA) there was no ignition, suggesting a difference in the bonding of Ta to these two agents.

The authors should be congratulated for following up so diligently after their intraoperative observation of this potential complication. Fortunately, it would be unusual for monopolar cautery to be used near embolized vessels. They did, however, note that with bipolar coagulation used at high power, there was also some evidence of

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combustion. Neurosurgeons operating on patients who have previously undergone embolization should be aware of this report and take proper precautions.

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The information contained in this report regarding the use of Onyx for preoperative arteriovenous malformation (AVM) embolization is extremely troubling. In one case, the Onyx in an extracranial vessel ignited and sparked when touched with the monopolar cautery. Laboratory testing confirmed the highly combustible nature of Onyx when combined with Ta powder. This risk of combustion is not seen with Ta-NBCA. Even before this report, I have not been impressed with Onyx as a liquid embolic agent for AVMs. The material is more likely to travel unintentionally into normal vasculature, the solvent dimethyl sulfoxide may be toxic, and the embolic material is prone to recanalization. The current report shows that Onyx has properties of flammability and self-sustained combustibility. It seems, therefore, that NBCA is a superior agent for preoperative AVM embolization and that Onyx may be contraindicated for this application.

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Meticulous testing of medical devices and products is pertinent before their clinical use. The enthusiasm and financial pressure to get new endovascular products to the market is extremely high and may lead to situations in which we really do not know what the long-term or, in this particular case, immediate adverse effects are. In many centers, AVMs are embolized preoperatively and then taken out necessitating the use of at least bipolar but usually not the monopolar cautery. The current report describes a very dangerous side effect that should have been detected earlier by the manufacturer rather than by the user.

Juha Hernesniemi
Mika Niemelä
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This report by Schirmer et al. describes the intraoperative ignition and self-sustained combustion of Onyx-embolized tissue when an Onyx-embolized occipital artery branch was coagulated with monopolar electrocautery. The authors performed an in vitro investigation to reproduce and further characterize this hazard. Samples of Onyx, Ta-depleted Onyx, Ta-NBCA, and Ta powder were exposed to monopolar and bipolar electrocautery in cut and coagulation modes at different power settings. Sparking and sustained combustion were reproduced in vitro by cut and coagulation monopolar modes in Onyx casts and free Ta-powder but not in samples of Ta-depleted Onyx or casts of Ta-NBCA. Ignition was similarly observed when using bipolar electrocautery, but only at higher energy settings. The authors concluded that sparking and combustion is a Ta-dependent process, and they recommended using Ta-NBCA rather than Onyx in situations mandating the use of a liquid embolic and high-energy electrocautery, pending the development of a safer radiopacifier for use with ethylene-vinyl alcohol copolymer. The findings of this report are of interest to all surgeons caring for patients who underwent previous embolization with Onyx. The authors should be commended on their work. The report is straightforward, identifying the problem and further characterizing the responsible agent and proposing a reasonable solution.

In the face of enthusiasm for using liquid embolic agents, this incidental observation is certainly worthwhile. It should incite alertness in all physicians using this agent because this phenomenon might have significant long-term consequences. This report should be spread to surgeons in other disciplines because Onyx is being used in other surgical specialties in which the use of monopolar cautery is routine (1–3). Although hazardous, similar circumstances remain exceedingly rare; monopolar cautery is almost never used intracranially. In our opinion, this report should also trigger a notice to all patients who have received Onyx; they should carry medic alerts like patients with diabetes and allergy. It is our expectation that future improvements in the development of embolic agents would earn wider safety measures and higher standards of analysis prior to clinical applications.

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