BRIEF COMMUNICATIONS

TOXIC FUMES FROM USE OF CAUTERY ON COLLAGEN- AND GELATIN-IMPREGNATED POLYESTER VASCULAR GRAFTS

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In recent years, successful surgery of the great vessels has become routine. In many instances, such as surgery for dissection of the ascending aorta, it may prove lifesaving. Vascular graft material of woven polyester impregnated with collagen or gelatin, with low porosity and good handling characteristics, has been adopted as the de facto standard for prostheses implanted to replace the intrathoracic aorta.

However, fashioning holes in these grafts, for example, in the reimplantation of coronary buttons in the modified Bentall procedure, has proved somewhat problematic. A common solution to this difficulty is now to use a hand-held high-temperature fine-tip electrocautery device.¹ The heated tip of such a device typically reaches a temperature of about 1200°C and, by pyrolysis, efficiently and precisely cuts a small area of graft material and seals the cut edge. The device can be used to excise a small disk of graft material, allowing tailoring of a hole for the accurate implantation of small vessels into the side of a larger vascular graft.

We noticed that during the use of such electrocautery devices on impregnated polyester grafts, noxious fumes were given off from the site of pyrolysis of the graft material. We have attempted to analyze these fumes for potentially hazardous constituents.

Methods. Portions of sterile vascular material were inserted into a sealed 20-mL glass vessel, with an electrocautery device inserted into the cap of the vessel. The graft material was subjected to pyrolysis at approximately 1200°C in two different environments for 1 minute: (1) in argon gas (with a small amount of residual air present) and (2) in air. The

gaseous products were extracted by means of a 1-mL gas chromatography syringe and injected into a Hewlett-Packard Engine gas chromatograph/mass spectrometer (Hewlett-Packard Company, Inc, Andover, Mass). Products obtained in argon were scanned for masses between 12 and 200 atomic mass units (amu). The products obtained in air were scanned from 33 to 200 amu. Product peaks were identified by means of the online Wiley mass spectrometry library. Two different graft materials were studied, labeled sample 1 and sample 2, from different manufacturers.

Results. The products of graft material pyrolysis, identified by the gas chromatograph/mass spectrometer, are listed in Table I in order of increasing elution time. Because of interference by oxygen and nitrogen from air, molecules of masses 32 or less could only be observed from products of pyrolysis in argon. For species of masses above 33, similar pyrolysis products were observed in air and argon, although the relative magnitudes of the peaks varied in the two gaseous environments. There were significant differences in certain pyrolysis products produced by the two differing graft material samples.

In addition to the compounds listed in Table I, traces of several hydrocarbons of carbon numbers C₃ to C₆ were detected, as well as small amounts of dihydrofuran and dimethyldisulfide.

Discussion. An important finding was that pyrolysis of both samples of graft material gave significant peaks of acetaldehyde and acrolein, both highly dangerous products. The former is a suspected carcinogen; the latter is highly toxic and can be fatal if inhaled in quantity. Sample 2 additionally produced a substantial peak identified as benzene, a probable carcinogen.

Although a small level of benzene was detected in pyrolysis of sample 1, the level did not significantly exceed the background level of benzene produced by a blank injection of air.

Sample 2 is a Dacron-based polyester of polyethylene terephthalate, and the observation of several aromatic products such as benzene, styrene, ethylbenzene, and benzoic acid is expected from the thermal decomposition of the terephthalate moiety. Terephthalic acid is 1,4-benzenedicarboxylic acid, which can readily eliminate carbon dioxide to form the monocarboxylic acid, benzoic acid. The latter would be expected to break down into benzene and other relatively stable aromatics. Sample 1 does not produce these aromatics and presumably is not based on polyethylene terephthalate.

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Fig 1. Total ion chromatogram of the pyrolysis products in argon from sample 2. Mass scanning is from 33 to 200 amu. (The toluene peak is an impurity arising from the gas chromatography syringe.)

We recognize that this study is qualitative and offers no quantitative information. Further quantitative studies (using calibrants for all products) of impregnated grafts and similar studies of nonimpregnated grafts are planned. However, even though this study is qualitative, we believe that concern should be expressed about the nature of the pyrolysis products of polyester grafts, especially benzene, acetaldehyde, acrolein, and

glycerol. Although they may be produced in only small quantities in the operating theater by the action of high-temperature cautery devices on polyester vascular grafts, they are irritant, highly toxic, or carcinogenic if inhaled. We suggest that these fumes should be scavenged from the surgical field, for example, with a high-volume surgical sucker, to minimize any risk associated with their inhalation.

Table I. *Pyrolysis products from samples 1 and 2 in order of increasing elution time with gas chromatography/mass spectrometry*

<i>No.</i>	<i>Compound</i>	<i>Present in sample 1</i>	<i>Present in sample 2</i>	<i>Comments</i>	<i>Reference</i>
1	Methane	Yes	Not measured	Flammable	
2	Carbon dioxide	Yes	Yes	Peak height very much higher than from an air blank injection	
3	Ethylene	Yes	Not measured	Flammable	
4	Acetylene	Yes	Not measured	Flammable	
5	Carbon monoxide	Yes	Not measured	Toxic	
6	Acetaldehyde	Yes	Yes	Significant peak, suspected carcinogen	2
7	Water	Yes	Yes		
8	2-Propenyl	Yes	Yes	Common name, acrolein; significant peak, highly toxic	2
9	Vinyl ether	No	Yes	Highly flammable, toxic	3
10	Furan	No	Yes	Highly flammable, toxic, and suspected carcinogen	3
11	Benzene	Small or absent	Yes	Peak approximately background level in sample 1; large peak in sample 2; suspected carcinogen	2
12	Ethylbenzene	No	Yes	Toxic, narcotic	2
13	Styrene	No	Yes	Toxic, suspected carcinogen	2
14	1,2,3-Propanetriol	Yes	Yes	Major peak; common name glycerine; irritant in high concentrations	2
15	Unidentified, probably an ester of benzoic acid	No	Yes		
16	Benzoic acid	No	Yes	Corrosive, severe eye irritant	2

REFERENCES

1. Kouchoukos NT, Marshall WG Jr, Wedige-Stecher TA. Eleven-year experience with composite graft replacement of the ascending aorta and aortic valve. *J Thorac Cardiovasc Surg* 1986;92:691-705.
2. Chem Alert II, version 2.2.4. Risk management technologies. Australia: November 1999.
3. Chem Watch, version 2.2. Chem Watch Australia. Caulfield North, Victoria, Australia: 1998.