

FIBER EMBOLIZATION — A HAZARD OF CARDIAC SURGERY AND CATHETERIZATION

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DURING the past 10 years, we have observed that anisotropic intra-arterial fibers, similar to cotton or cellulose fibers, are a common incidental finding in pathological specimens, found almost exclusively in post-mortem examination of patients who have undergone cardiac operations or catheterization. This report was prompted by the recent occurrence in two patients of thrombosis and infarction that were associated with these fibers, indicating that the presence of the foreign material is neither artifact nor innocuous.

METHOD

The minimum incidence and the site of fiber embolization were determined by review of the autopsy records from 1964 to 1973 of all patients on whom cardiac operations or catheterization or both had been performed.

Because we had noted a similarity between fibers in pathological specimens and cotton fibers, we hypothesized that materials used or worn during cardiac surgery or catheterization might be the source of the intravascular fibers. Therefore, fibers of various cotton and disposable paper materials used during cardiac operation or catheterization were examined microscopically and compared to those in pathological specimens.

We assessed the ease by which fibers are shed from each material by agitating by hand each intact, recently cleaned or un-packaged specimen for one minute over a clean basin containing 100 ml of water. A 10-ml aliquot was then removed and filtered through a 5- μ m filter.* Filter membranes were placed on clean microscopical slides and cleared with chloroform, and then the slide was allowed to dry in a closed chamber. Controls were handled in the same manner. They were obtained from a 100-ml volume of water that was allowed to stand uncovered for one minute. Control samples were obtained at the onset and after every second specimen. Once dry, all slides were examined with a microscope with use of a polarizing filter. The number of fibers trapped by the membrane filter was determined and graded as follows: 1+ (zero to 15); 2+ (16 to 30); 3+ (31 to 45); and 4+ (46 and greater). Saline wash obtained from the pump oxygenator after operation was also examined for fiber content with use of 10 ml of prefiltered distilled water as a control.

RESULTS

Fourteen (8 per cent) of 173 patients who had undergone cardiac operations or catheterization, or both, had fiber emboli in routine autopsy sections. All 14 patients had previous angiographic examinations; eight had also had intracardiac operations, three had had extracardiac procedures such as pulmonary-artery banding, and three patients had not been operated on. Fibers occurred most commonly in pulmonary arteries (eight cases) but were

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also found within renal (four cases), cerebral (one case) and mesenteric arteries (one case). These fibers were readily distinguished from talc or starch. When they were found in patients who had died during or immediately after an intracardiac procedure there was no associated inflammation, and there may or may not have been thrombus. At a somewhat later stage, the fibers elicited a typical intravascular foreign-body inflammatory reaction (Fig. 1). Regardless of the type of reaction, the embolized fiber and the associated reaction often resulted in narrowing or occlusion of the vascular lumen.

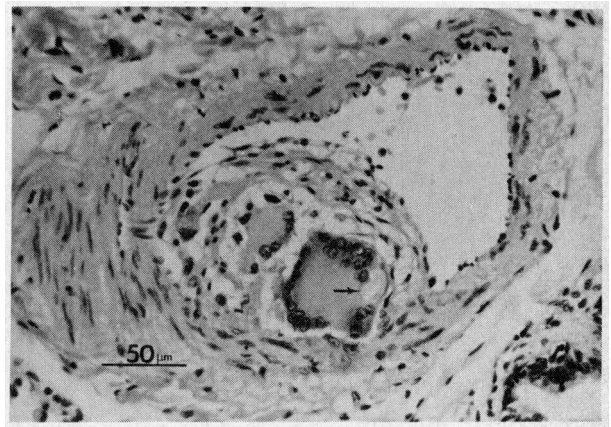


Figure 1. Intravascular Foreign-Body Granuloma Containing an Intracytoplasmic Anisotropic Embolic Fiber (Arrow) in a Small Pulmonary Artery (Hematoxylin and Eosin Stain).

The vessel lumen is appreciably narrowed. Angiocardiology had been performed three weeks before death. There was no operation.

Fibers removed from cotton and paper materials were either straight or twisted, and many appeared to have a less birefringent central core. Cotton fibers were more homogeneously birefringent than paper fibers and were less variable in width: cotton fibers, 2.3 to 29.9 μ m; and paper, 2.4 to 40.1 μ m. Shed cotton and paper fibers were identical in appearance to fibers extracted from the fabrics and were of similar widths: cotton fibers, 3.3 to 22.2 μ m; and paper fibers, 3.9 to 36.1 μ m. In pathological specimens fibers varied from 3.8 to 14.8 μ m in width, were of variable length and, like the shed fibers, were identical to those within the fabrics examined, although the distinction between cotton and paper was less apparent. No fiber, short or long, bore any resemblance to birefringent talc or starch granules.

In the assessment of materials used in the operating room, all drapes, gowns, caps, masks and sponges tested, whether cotton or paper, readily shed fibers upon agitation (3+ or 4+). There was no difference in shedding qualities between cotton and disposable paper. No difference in fiber count was found between control specimens (1+) and the saline wash from the pump oxygenator (1+). The presence of small numbers of fibers entrapped by the filter membrane from all control specimens was attributed to contamination by airborne fibers.

DISCUSSION

Among the many materials other than thrombi that may embolize,¹⁻³ cotton-fiber embolization has been documented pathologically and produced experimentally,⁴⁻¹⁵ but the occurrence of fiber emboli apparently is not appreciated generally. Cotton fibers have been considered to come from cotton gauze and sponges. Embolization has occurred during intravenous therapy^{4,5,6,9} and angiography.¹¹⁻¹⁵ Fiber emboli have, in the past, been attributed to the use of cotton filters during intravenous therapy,⁶ and, with the advent of angiography, contamination of irrigation fluid and adherence of cotton fibers to catheter guides wiped with gauze have been reported.^{14,15} Emboli of cotton fibers may induce no pathologic response or may produce intravascular thrombosis, intimal foreign-body granulomas or intimal fibrosis, and may penetrate the vessel wall.⁴⁻¹⁵ Although considered to be of no clinical consequence,⁵ cotton-fiber embolism has been the cause of cerebral and renal infarction in patients who underwent angiographic examinations^{11,14} and was associated with multiple pulmonary infarcts in a patient who had numerous intravenous injections.⁶ Multiple infarcts of the kidney also have been produced experimentally with intravascular administration of cotton fibers.¹⁴

In the survey population of 14 patients we encountered one serious complication that could be attributed to fiber embolization. Multiple foci of cerebral necrosis were present in this patient, who had numerous fiber emboli within small cerebral vessels (Fig. 2). The fibers were commonly bound by thrombus and were closely associated with the zones of cerebral necrosis. As mentioned, two recent additional patients have had infarcts associated with embolic fibers. Long fibers were present within a thrombus that occluded a major pulmonary artery, resulting in pulmonary infarction in one patient who died shortly after a corrective operation for tetralogy of Fallot. In another case, multiple birefringent fibers were present within a thrombus removed from the occluded radial artery of a patient in whom ischemia of the left hand developed 24

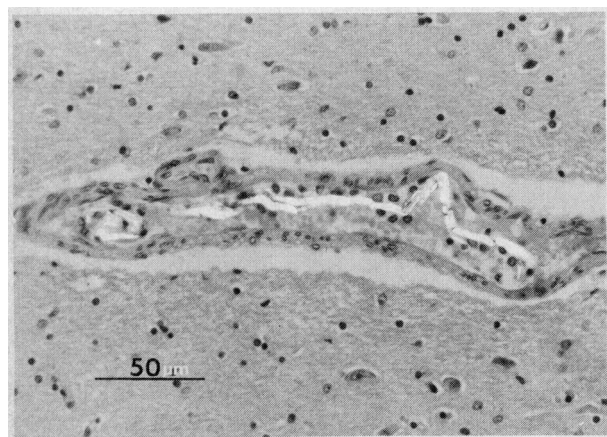


Figure 2. Cerebral Artery Containing a Long Fiber Embolus (Hematoxylin and Eosin Stain, Polarizing Filter).

Foci of cerebral necrosis were adjacent to vessels containing fiber emboli. The patient died 24 hours after an open-heart operation.

hours after the artery had been cannulated during an intracardiac operative procedure. The subsequent development of gangrenous necrosis necessitated amputation of the hand, and within the distal radial artery the birefringent fibers were again found in thrombotic material.

Fibers in pathological specimens are identical in appearance to those shed from materials used in cardiac operations and catheterization. We propose, therefore, that fibers dislodged from fabrics used or worn during such procedures enter the cardiovascular system through direct contact of sponges or towels, settle from the air, or are introduced in solutions contaminated by fibers.

At this institution, one case each of fiber embolism has been documented at autopsy in patients who had multiple exchange transfusions or extensive intravenous therapy. Fibers may also be shed into surgically exposed tissues outside the cardiovascular system, provoking a granulomatous reaction limited to the operative field.

The incidence and morbidity of fiber embolization demonstrated in this study in addition to the morbidity previously documented^{6,11,14} suggest that preventive measures should be considered. Thus, the fiber-shedding quality of cotton and paper materials used during operation or catheterization should be diminished, or if such a reduction is not possible, nonshedding fabrics might be developed or substituted. Furthermore, solutions used for the purpose of intravascular injection or catheter irrigation should be kept closed to prevent contamination by fibers.^{14,15}

A recent study documented a high content of particulate foreign material, including cellulose fibers, in the effluent from many of the pump oxygenators in current use.¹⁶ The observation that routine preoperative flushing of the bypass oxygenator resulted in only a slight decrease in postoperative neurologic deficits (from 14.3 to 10.7 per cent) suggests that other important sources of particulate material remain. During the period of observation covered in this study, we have routinely employed preoperative flushing of our bypass oxygenator with sterile saline. We have now abandoned the use of an open-basin reservoir of sterile saline for irrigation and converted to closed-bottle supply. We are trying a polyester urethane filter with an effective pore size of 27 μm in the arterial line during bypass.

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BY THE LONDON POST

The Public Health—Continuing Discord— Crash Call

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IN his first annual report¹ as chief medical officer at the Department of Health, Dr. Henry Yellowlees, who succeeded Sir George Godber, reviewed the trends in the state of the public health during 1973.

The most striking demographic feature of recent years has been the continuous fall in the annual number of births, which began in 1964, the birthrate of 13.7 per 1000 in 1973 being the lowest ever recorded in peacetime. This current fall in fertility has affected women of all ages and all parities, and it is thought that there may be a number of contributory factors. Improved family planning has certainly enabled couples to exercise greater control over family size; the spacing of children and hence family formation patterns are now becoming more closely related to prevailing economic and social conditions than in the past. The availability of contraceptive advice and the introduction of the Abortion Act have doubtless helped to reduce the number of illegitimate births, but 8.6 per cent of all live births in 1973 were illegitimate and those occurring in women under 20 years of age accounted for 35.5 per cent of all illegitimate live births. Maternal and perinatal mortality rates have also fallen, the maternal mortality rate from 0.14 per 1000 total births in 1970 to 0.10 per 1000 in 1973, and the perinatal mortality rate (stillbirths and deaths in first week of life) from 23.5 per 1000 births in 1970 to 21 in 1973. Over the same period the proportion of women delivered in hospital has risen from 88.8 to 93.7 per cent, and there has been a distinct increase in the number of assisted deliveries. Thus, in 1965, it was estimated that 8.3 per cent of hospital deliveries were performed with the aid of forceps, 5 per cent were by cesarean section, and labor was artificially induced in 15 per cent of hospital deliveries. In 1972, 11.2 per cent of deliveries were forceps assisted, and 5.3 per cent were by cesarean section; nearly one third of all hospital deliveries were artificially induced.

This trend toward planned induction of labor has been the subject of considerable public comment, and it was hinted that inductions were being performed for the convenience of hospital staff, particularly over holiday periods. This suggestion was much resented, both by the ob-

stetricians and by the midwives, who claimed that they remain as dedicated as ever to their work. In a parliamentary statement,² Dr. David Owen, for the Department of Health, said that he had no direct evidence to support newspaper allegations that some hospitals were inducing births so that maternity departments could close for Christmas. Nevertheless, the shortage of nursing staff and the effects of recent reductions in working hours, as well as increased leave entitlement, inevitably create new staffing problems; obstetricians must review their policies in the light of available resources, but the favorable trends both for maternal and for infant mortality provide some vindication of the policies being developed.

As compared with these improvements in the chance of infant survival, the death rate showed only a marginal improvement in 1973, falling from 12.0 to 11.9 per thousand population. Cardiovascular disease continued to account for about 50 per cent, cancer for about 20 per cent and respiratory disease for about 15 per cent of all deaths. Lung cancer was responsible for 41 per cent of all male cancer deaths and has now become the second commonest cause of cancer mortality among women. It is also interesting that deaths from tuberculosis, prostatic hypertrophy, hypertension and suicide have decreased in recent years, reflecting the efficacy of public-health measures and antibiotics in the management of tuberculosis, improved surgical technique and medical management in that of prostatic hypertrophy, effective drug therapy in hypertension and successful intensive therapy after attempted suicide. On the other hand, it is disturbing to find that deaths from cirrhosis of the liver, thromboembolic disease and meningococcal infection have definitely increased. The increase in cirrhosis may be associated with the increase in alcoholism as manifested by a rise in the number of patients admitted to mental hospitals with a primary diagnosis of alcoholic psychosis or alcoholism from 5947 in 1968 to 9595 in 1972; the contraceptive pill is presumably a contributory factor in the increasing prevalence of thromboembolism, but it is likely that there is also a greater awareness of the manifestations of thromboembolic disease; the higher mortality rate in meningococcal infections is associated with an increased prevalence of such infections in England and other European countries, with a rising proportion of sulfonamide-resistant strains.

The risk of importing infectious diseases from overseas was shown by the notification of small numbers of cases of cholera, malaria, typhoid and paratyphoid contracted abroad, and five cases of smallpox were confirmed in 1973. The first was in a man who returned to London from Calcutta and was subsequently found to be suffering from variola major. He was well vaccinated, his illness was mild, and he made an uneventful recovery; contacts were few, and no secondary cases occurred. The other four cases arose from the accidental infection of a female laboratory technician who had been present in a laboratory where pox viruses were being harvested. Ten days later she became ill and was admitted to a ward in a general hospital with pyrexia of unknown origin. Skin lesions from which pox virus was isolated later developed, and she was transferred to a smallpox hospital. Her illness took a highly modified form, and recovery was complete. While this