TENSILE STRENGTH OF IRRADIATED FREEZE-DRIED ARTERIAL GRAFTS

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For several years in Leeds arterial homografts have been preserved by sterilization in β -propiolactone followed by freeze-drying and storage *in vacuo* (Flewett *et al.*, 1955; Zinnemann, 1957). Bacteriological and histological tests on these arteries after reconstitution have shown satisfactory sterilization and preservation of structure. Tensiometer tests have revealed a significant gain in tensile strength (unpublished observations).

Recently we have been interested in the application of γ -radiation from a cobalt or caesium source to the sterilization of arterial homografts. This paper deals with the effects of such irradiation on the tensile strength of freeze-dried human aortas.

Methods

Aortas from young cadavers were obtained without sterile precautions. Two equal lengths were taken from each aorta and freeze-dried separately by the single-stage method (Flewett *et al.*, 1955). One length from each aorta was sent to the Wantage Radiation Laboratory, where it was exposed in its tube to a dose of γ -radiation from ^{60}Co source at either 20° C. or -15° C. The other length of each aorta was retained as a control. Finally all arteries were reconstituted with physiological saline solution, and six to nine 1-cm. rings were cut from each aorta with a double-bladed guillotine. The rings were suspended between two wire hooks attached to a Denison textile tensiometer. The wires were distracted at constant speed and the breaking load of each aortic ring was recorded in pounds.

Results

Preliminary work on the tensile strength of aortic rings had shown no significant difference between the strength of the thoracic and that of the abdominal aorta. It had also shown that significant weakening occurred in aortas exposed to 2.5×10^6 rad, 2×10^6 rad, and 1.5×10^6 rad. It is certain that a smaller dose than 2×10^6 rad cannot be relied on to sterilize tissues—and this dose will not sterilize freeze-dried cultures of clostridia (A. J. H. Rains, personal communication). It was therefore decided to test the effect on tensile strength of 2×10^6 rad γ -radiation on five aortas at 20° C. and five at -15° C. The results are shown in Tables I and II. It is clear that irradiation causes weakening, more marked at 20° C. but still significant at -15° C.

Discussion

The possibility of using ionizing radiation for the destruction of micro-organisms in arterial grafts was first mooted by Meeker and Gross (1951a, 1951b). These authors irradiated five fresh dog arterial segments with 1.5×10^6 rep (equivalent to about 1.4×10^6 rad) of high-

energy electrons at room temperature. When these segments were grafted into dogs they failed owing to thrombosis in each case. On the other hand, 38 aortic grafts irradiated with 1.5 to 2×10^6 rep at -80° C. were transplanted into the abdominal aortas of dogs with only one failure.

Buchanan and Marrangoni (1955) irradiated freeze-dried arterial segments with 2×10^6 rep of γ -radiation from ^{60}Co source. They found that when these grafts were reconstituted they were sterile and usable, and that there were no histological changes. They did not record the long-term results of implanting these arteries in dogs.

The destructive effects of irradiation on tissues are threefold: (1) Ionization of organic molecules with direct breakdown of tissues. (2) Ionization of water molecules with the production of free H^+ , OH^- , and

TABLE I.—Arteries Irradiated at 20° C.

Artery No.	Mean Tensile Strength (lb. per cm. Ring)		Mean Difference (lb.)	t	n	p
	Control	Irradiated				
1	7.17	4.17	3.00	8.89	12	<0.001
2	5.63	3.70	1.93	4.87	12	<0.001
3	5.89	3.49	2.40	4.23	16	<0.001
4	7.96	4.80	3.16	6.51	14	<0.001
5	5.19	4.30	0.89	2.53	12	<0.05 >0.02
1-5	6.38	4.07	2.31	8.53	74	<0.001

TABLE II.—Arteries Irradiated at -15° C.

Artery No.	Mean Tensile Strength (lb. per cm. Ring)		Mean Difference (lb.)	t	n	p
	Control	Irradiated				
1	6.84	5.84	1.00	1.55	12	<0.2 >0.1
2	7.07	4.66	2.41	4.54	12	<0.001
3	7.96	6.16	1.80	2.54	12	<0.05 >0.02
4	8.78	7.05	1.73	2.38	10	<0.05 >0.02
5	8.70	7.17	1.53	2.63	12	<0.05 >0.02
1-5	7.84	6.15	1.69	4.96	66	<0.001

other ions, which cause oxidation and reduction effects. (3) The direct heating effect of electron irradiation. This effect is negligible with γ -radiation sources because they take longer than electrical machines to achieve the desired dose.

It was hoped that by irradiating freeze-dried material (water content under 4%) at a reduced temperature the latter two effects could be eliminated and sterility obtained without structural damage. The reduction in tensile strength demonstrated in this series apparently reflects damage not detectable histologically. As our results with β -propiolactone sterilized freeze-dried arteries show an actual increase in tensile strength, we shall continue to prefer this method.

Summary

Ten human aortic segments have been freeze-dried and then exposed *in vacuo* to 2×10^6 rad of γ -radiation from a ^{60}Co source.

Five of these grafts were irradiated at 20° C. and five at -15° C.

The tensile strength of rings of each aorta with its control non-irradiated aorta was tested on a Denison machine.

In each case a reduction in strength was found in the irradiated compared with the control artery.

It is suggested that γ -radiation at 20° C. or at -15° C. is an unsatisfactory sterilizant for arterial homografts.

The tensile strength measurements were carried out by one of us (A. V. P.) in the Department of Textile Industries of the University of Leeds. We are greatly indebted to Professor J. B. Speakman and Mr. W. J. Onions for their help and advice.

REFERENCES

- Buchanan, J. L., and Marrangoni, A. G. (1955). *Surgery*, 38, 999.
Flewett, T. H., Zinnemann, K. S., Oldfield, M. W. C., Shucksmith, H. S., and Dexter, F. (1955). *Lancet*, 1, 888.
Meeker, I. A., and Gross, R. E. (1951a). *Surgery*, 30, 19.
— (1951b). *Science*, 114, 283.
Zinnemann, K. (1957). *Univ. Leeds med. J.*, 6, 116.

VULVAL VARICOSE VEINS IN PREGNANCY

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The proportion of young women who first develop or show deterioration of varicose veins of the legs during pregnancy is high. In the antenatal department of University College Hospital a weekly varicose vein clinic has been established to advise mothers concerning this condition and to attempt, by antenatal care, to reduce the incidence of puerperal phlebitis and thrombosis.

This varicose vein clinic received about 8% of all women booked for antenatal care during the period 1955-7 (343 cases of varicose veins from a total of 4,267 bookings). This figure does not represent the true incidence of the condition, for only those women who complained of pain or disfigurement, or whose condition was so severe that it attracted attention at the routine blood-pressure examination, were referred to the vein clinic. Hence the figure of 8% in this selected group is a conservative one, and the proportion of women with some degree of incompetence is probably nearer 12%, or even higher. This high incidence is especially important when it is remembered that the majority of women accepted for antenatal care are young primiparae; in multiparae, who are not usually seen in hospital, the proportion with varicose veins must be higher.

Though varicosities of the leg veins in pregnancy are widely recognized, involvement of the veins of the vulva have hitherto received little attention. During the routine examination of the women in the antenatal clinic, however, the frequency of such varicosities has impressed itself upon us. The probable reason why the condition has so far apparently been overlooked is due to the natural reticence of most of the women, who nevertheless are often extremely uncomfortable because of the bulk, tension, and warmth of one or both labia majora, especially in the posterior part.

Of the 343 women seen in the varicose vein clinic, 80 (23.3%) had involvement of the vulva. This varied from a single node on the margin of the labium major

to a mass of varices causing so much swelling that walking was difficult because of chafing of the dependent labia. Analysis of these 80 cases for (1) site of varicosity, (2) week of gestation when first observed by the patient, and (3) parity of the patient are set out in the Table, together with similar figures

Analysis of Varicose Veins in Pregnancy

Site	Week of Onset	Parity
<i>Vulval Varicosities (80 Cases)</i>		
Right side .. 40 (33%)	12-26 weeks 46 (19.5%)	Para 0 .. 15 (11.8%)
Left .. 31 (27.5%)	27 weeks-term 34 (32%)	.. 1 .. 31 (28%)
Both sides .. 9 (8.5%)		.. 2 .. 13 (28%)
		.. 2+ .. 21 (37%)
<i>Leg Varicosities (343 Cases)</i>		
Right side .. 121	12-26 weeks 237	Para 0 .. 127
Left .. 113	27 weeks-term 106	.. 1 .. 112
Both sides .. 109		.. 2 .. 47
		.. 3 .. 57

The percentages are based on the number of women with corresponding leg varices

for leg varices in the 343 patients examined. It will be seen that there is little difference in incidence between the right and left sides, and that the majority developed after the 26th week of gestation. Though the figures for parity are not a true indication of incidence, for, as stated earlier, primiparae predominate in the antenatal clinic, the figures available show clearly that multiparous women suffer more frequently from vulval varicose veins than do women having their first child.

Treatment of Varicose Veins in Pregnancy

The treatment of varicose veins in pregnancy resolves itself into expectant and operative measures. Most of the patients referred to one of us (H. D.) had gross distressing varices that were not responding to bandaging, elastic stockings, injections, and extra rest. In many instances the home circumstances required the mother's services until the day of delivery, whilst a few patients had veins which were unrelieved except by continuous recumbency for the last 6 to 12 weeks of pregnancy. These groups have been treated operatively.

In considering varicose veins in pregnancy, a diagnosis is first required. Most of these patients had frank incompetence of the long saphenous vein; it was often present before conception. An impulse was palpable in their veins when they coughed. Percussion of the long saphenous vein at the groin gave a discernible impulse in varices of the leg. The tourniquet tests gave down-filling waves or cascades. Fifty such patients have been treated by a flush sapheno-femoral ligation and destruction of the saphenous trunk; since December, 1951, it has been by stripping. Three patients who had incompetence of the short saphenous vein had a sapheno-popliteal ligation and stripping to the ankle.

Varicose Veins of the Vulva

Varicose veins of the vulva are an embarrassing form of varicosity which is distressing mentally and physically. Vulval veins may be distended from one or more of three sources of hypertension. (1) The long saphenous vein through its incompetent tributaries, the superficial and deep external pudic veins. (2) The spermatic veins passing with the round ligament from the labia majora into the inguinal canal and thence to the posterior abdominal wall to join the inferior vena cava on the right and the renal vein on the left. Their varicosity causes a bulge in the groin like an inguinal hernia, with an increasing pear-shaped swelling of the