define certain rational grounds upon which operation should be undertaken urgently and resolutely.

Summary

Nine cases of acute traumatic limb ischaemia are presented. In spite of the fact that technically successful arterial repairs were performed in the majority, only three of the affected limbs were saved.

The pathology is reviewed and the causes of the failures are examined. Some are unavoidable because of associated soft-tissue injury, but the majority are attributable to simple delay in restoring blood-flow.

The reasons for this delay are discussed. It is felt that the aetiological role of arterial "spasm" in such cases has been overemphasized, to the detriment of their prompt and effective treatment.

A suggested scheme of management is outlined.

APPENDIX

Since submitting this article two further cases of acute ischaemia resulting from trauma have been encountered.

In one patient, a labourer aged 50, the axillary artery had been damaged by an injury to the shoulder. Operation was undertaken about four hours after the injury, and it was found that pulsation in the axillary artery extended down to a segment of narrowed contused artery beyond which the axillary artery was diminished in calibre and non-pulsatile. Exploration showed that continuity of the axillary artery was maintained only by a cuff of adventitia within which lay a thrombus effectively sealing the artery. The damaged portion was excised and the artery reconstructed by end-to-end anastomosis. An excellent result was obtained. In effect, the injury had completely severed the artery, and the ends were held in proximity by the adventitia; the outward appearances resembled some descriptions of "spasm" of the artery.

The other patient, a labourer aged 52, was first seen 14 hours after a severe crushing injury confined to the thigh. At this time there was complete ischaemia of the leg and foot with gross swelling and contracture of the leg muscles. At operation, traumatic thrombosis of the femoral artery at the adductor hiatus was found; the clot was removed from within the artery and a good popliteal flow restored. In view of the gross ischaemic damage to the leg, nothing further was done. Over the next 12 days the popliteal artery remained open, but massive septic necrosis of the leg muscles became apparent and the foot showed extensive gangrene, although two toes survived. A below-knee amputation was undertaken, during which a copious blood supply was encountered. In this patient the extensive injuries to the thigh had interfered with collateral circulation, so that occlusion of the main artery had caused almost complete ischaemia for 14 hours. Recognition of this ischaemia and relief by surgery within 6 hours of the injury might have saved the limb.

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INCIDENCE OF CHRONIC ARM OEDEMA AFTER TREATMENT FOR BREAST CANCER

BY

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Survival has long been the main criterion of success in cancer treatment. But morbidity should be considered as well as survival time. Five-year survival figures give no indication of the degree of discomfort that patients may suffer during that time. When some of this discomfort can be attributed to the method of treatment itself, full regard should be paid to this possibility when undertaking it. In this series of patients with breast cancer the morbidity due to swelling of the arm has been studied.

Arm-swelling is a common sequel to treatment for breast cancer and is often observed in the follow-up clinic, but the frequency with which it occurs has rarely been estimated with any accuracy. A wide range exists in the figures quoted for its incidence: from 8% (Aird, 1957) to 80% (Lobb and Harkins, 1949). This discrepancy is partly explained by different definitions of what represents a significant amount of arm-swelling.

Aird (1957) says that "arm-swelling is present to a considerable degree in only 8% of patients who survive five years." The definition of "a considerable degree" refers to Devenish and Jessop's (1937) study of 90 patients, of whom seven had sufficient swelling to "render the limb heavy and fatiguing to use, to cause disfigurement, to necessitate the wearing of special sleeves, and to produce undue susceptibility to inflammation."

Holman, McSwain, and Beal (1944) found that 44 out of 100 unselected patients had more than a 3-cm. increase in arm circumference measured 10 cm. above and below the olecranon process. Daland (1950) found that 22.5% had more than 2.5 cm. difference, but this group of 90 patients was selected more from his private than from his clinic practice. In Nicolson and Grady's (1948) review of 905 cases of carcinoma of the breast, 273 patients were surveyed for arm swelling and 36% had "slight," "moderate," or "severe" swelling.

The importance of arm-swelling as a symptom is rarely mentioned. Holman *et al.* (1944) give figures for "good," "fair," or "poor" arm function in relation to the degree of swelling. They point out that a significant degree of swelling may exist without recognition, unless measurements are made. On the other hand, when considering morbidity, the subjective aspect may be more important than the objective. Nevertheless, unnoticed arm-swelling, or swelling that is no inconvenience to the patient, may obviously be accepted in the treatment of breast cancer. Furthermore, subjective evidence is chiefly of individual significance and is not readily susceptible to statistical analysis. The subjective figures in this present series are of doubtful value, therefore, though it is important to consider subjective symptoms in a study of morbidity.

Method

To avoid any subsequent bias from taking the measurements, the subjective evidence was collected first. The patients were asked: "Is your arm swollen?" If they answered yes, they were then asked: "Does it bother you much, little, or not at all?" Patients would not always agree to this form of words, and often began complaining of discomfort in the axilla or shoulder, but it was usually possible to tie them down to an assessment of the arm-swelling itself in those words. They were also asked if they were left- or right-handed, since it seemed reasonable to suppose that the dominant arm might have a greater circumference than the other because of activity alone.

It was necessary to have a precise definition of arm-swelling. Probably the most accurate assessment is by measuring the volume of the arm by displacement of water (Stillwell and Redford, 1959). This is not practicable in a busy follow-up clinic, and so it was decided to measure the circumference of both arms above and below the elbow. Holman *et al.* (1944) measured at levels 10 cm. above and below the tip of the olecranon process, and this was repeated in the present series. They regarded a difference in circumference of more than 3 cm. as significant, but in this series 2.5 cm. was chosen because a short study of control patients and staff had shown none to have more than 2-cm. difference under normal circumstances.

Selection of Patients

Some of the figures given in earlier series were from selected patients while others were from comparatively small series. The object of this inquiry was to obtain reliable data by studying a large number of unselected patients. The follow-up clinic of the radiotherapy department in Oxford provided an opportunity for assessing the morbidity rate, since, with few exceptions, the general surgeons refer all patients with breast cancer to the department and these are all subsequently followed up. Usually the patients received post-operative radiotherapy, though a number had radiotherapy alone and a few were treated pre-operatively. It is reasonable to assume that almost every patient with breast cancer would attend the follow-up clinic in the course of a year's study. It is considered, therefore, that data on patients attending the follow-up clinic during one year would give reasonably accurate information on the true incidence of arm-swelling in the Oxford area.

The survey comprised 305 patients. This figure is lower than the total number of patients with breast cancer followed up in Oxford during one year, because of the exclusion of: (1) Oxford patients who had moved elsewhere and, though followed up, were not seen at our clinic; (2) patients who attended for follow-up but who had originally been treated at other centres, where surgical and radiotherapeutic techniques may have been different; (3) patients dying before coming into the inquiry; (4) patients failing to attend; and (5) patients with swelling due to cancerous invasion of the axilla. It is reasonable to claim that only in this last group was there any selection. Since the object of this survey was to study morbidity due to treatment rather than disease, this last group with neoplastic

lymphoedema was necessarily excluded. The 305 patients thus form an unbiased sample.

Procedure

The study was conducted during the year from April 1, 1958, to March 31, 1959. The patients were seen at least nine months after the beginning of their first surgery or radiotherapy. This period was chosen to give time for all forms of treatment to be completed and for any temporary arm-swelling to subside (Parker, Russo, and Darrow, 1955). In addition to the subjective inquiry and arm measurements, the three classes of surgical treatment were distinguished (radical mastectomy, local mastectomy, or none); and the treatment or not of the axilla by radiation and the histological finding of axillary lymph-node involvement were noted.

Results

Of 305 patients measured, 109 (36%) were found to have 2.5 cm. or more difference between the circumferences of their arms. These measurements are analysed in Table I.

These numbers can be divided into two approximately equal groups: 58 patients with 2.5-5 cm. of swelling and 51 with more than 5 cm. This division has been used in Table II, where the data are analysed with respect to the various factors.

In Tables III and IV the subjective symptoms are considered.

TABLE I.—Analysis of Measurements

Diff. in circumference (cm.)	2.5-5	5-	7.5-	10-	12.5-15	Total
No. of patients	58	29	13	7	2	109 (36%)

TABLE II.—Analysis of Factors

	Total No.	Cases of Arm-swelling		
		2.5-5 cm.	5+ cm.	Total
Nodes cancerous	135	38	30	68 (50%)
" clear	135	19	19	38 (28%)
" not examined ..	35	1	2	3 (8%)
Radiotherapy:				
Had treatment to axilla	211	50	46	96 (46%)
No	94	8	5	13 (14%)
Surgery:				
Radical mastectomy ..	253	54	49	103 (41%)
Local	41	4	1	5 (12%)
No operation	11	0	1	1 (9%)
Arm involved:				
Dominant side	139	30	24	54 (39%)
Other	143	25	24	49 (34%)
Bilateral cancer ..	23	3	3	6 (26%)

TABLE III.—Subjective Data

	Possible Total	Actual No.
Correlation of subjective awareness with objective evidence of significant swelling	109	91 (83%)
Unaware of significant swelling	109	18 (17%)
Subjective symptoms, but no significant swelling ..	196	48 (24%)

TABLE IV.—Subjective Symptoms Correlated With Amount of Swelling

Symptoms	Measurements	
	2.5-5 cm.	5 cm. or more
Unnoticed	16	2
No trouble	20	11
Little	21	26
Much	1	12

Discussion

The 36% incidence of a defined degree of arm-swelling in an unselected series of patients treated for breast cancer approximates to a true morbidity rate, for the Oxford area at least. It is identical with the figure from Nicolson and Grady's (1948) comparable series of 276 patients. This shows that, with the present orthodox methods of treating breast cancer, one-third of the patients may expect a significant amount of arm-swelling afterwards.

Of the 109 patients with oedema, 60 (55%) complained of some inconvenience from this symptom, but most of these had only a little trouble. As might be expected, a greater amount of swelling was associated with more severe symptoms (Table IV). The subjective evidence is less reliable, of course, but there was a high positive correlation (83%) between the objective and subjective assessments. *Arm-swelling is thus a common symptom after treatment for breast cancer though it is often endured without great distress.*

Table II shows to what extent the incidence of arm-swelling is increased by the various factors: cancerous axillary lymph nodes (50%:28%); radiotherapy to axilla (46%:14%); and radical rather than local mastectomy (41%:12%). It shows that it made no difference to the patient which arm was involved. (In fact, only five patients were left-handed, and two were ambidextrous, so that the dominant side was usually the right.)

Though it would be useful to be able to assess the individual contributions of these various factors, the percentages in Table II must be interpreted with care. This is because many of the patients received both radical surgery and radiotherapy for their breast cancer, and many of these will have had cancerous axillary lymph nodes. Thus all the three factors may be operating to a varying extent in the same patients, and these data can only provide relative figures for the influence of each. Even these may be misleading.

This point is illustrated by Table V, which shows how a more detailed analysis of the data may suggest different conclusions. After radical mastectomy and radiotherapy the incidence of arm swelling is seen to be identical, whether the axillary lymph nodes are found to be cancerous or not. After local mastectomy with radiotherapy the percentage is seen to be similar to the figure for those patients having no radiotherapy after their surgery. Some of these groups are small, however, and the figures may again be misleading.

Unfortunately it was not possible to analyse the severity of the radiation reaction at the axilla in these patients. At best this could only be done quantitatively, and in most of these patients the assessment would have been retrospective. But though they all receive the same nominal dose of x-rays, some patients suffer a

more severe reaction in the axilla than others, and this may lead to a degree of fibrosis. Similarly some patients may have undergone a more "radical" radical mastectomy, which also may be followed by a tighter axillary scar. Here again only a qualitative assessment of the operation is possible, and this would require a surgical opinion, preferably by the same surgeon observing every case. It may well be that such a study of the severity of the x-ray reaction and the extent of the surgical dissection at the axilla, however qualitative, would provide the most important information about the aetiology of this arm-swelling.

Aetiology

In this series a significant degree of arm-swelling is attributable to the following factors: post-operative x-ray treatment to the axilla, cancerous involvement of the axillary lymph nodes removed at radical mastectomy, and radical mastectomy itself. (Swelling due to residual cancerous involvement of the axilla is another obvious factor, but the object of this study was to assess the morbidity of patients in whom there was no manifest involvement at the time of examination.) Unfortunately it was not possible to assess the contribution of post-operative infection and delayed healing in these patients, though the literature suggests that these are important factors.

It seems that any interference with the axilla (whether it be cancer, infection, surgery, or radiation) is likely to cause some disturbance of lymphatic and/or venous drainage in the axilla and that this is followed by swelling of the arm. Some of the previous literature on this subject is contradictory, however.

Veal (1937) classified post-radical mastectomy arm-swelling into three groups due to: (1) lymphatic obstruction, (2) constriction of the axillary vein, and (3) combined lymphatic and venous obstruction. Using venography, Veal (1938) found 90% of his cases were due primarily to venous obstruction. He made no lymphatic studies, however. Parker *et al.* (1955) found a direct relation between arm-swelling and increased venous pressure. They found that pressure increased immediately after operation and subsided in two to six months. On the assumption that this is a traumatic thrombophlebitis, they suggested "elastoplast" bandaging during this period and claimed that no patient had more than 2.5 cm. of swelling after this treatment. Again no lymphatic studies were made.

However, Devenish and Jessop (1941) found no evidence of venous obstruction in their cases. As well as measuring venous pressures they made lymphatic studies by dye injections, and concluded: "Lymphatic obstruction alone is sufficient to cause the swelling. Neither wound sepsis nor recurrent attacks of inflammation in the limb nor deep x-ray therapy is necessary for its development or persistence."

Nevertheless, post-operative infection and a severe radiation reaction in the axilla were factors in the series of 100 patients of Holman *et al.* (1944). Halsted (1921) also considered infection to be the main cause of "elephantiasis chirurgica," and he suggested a modified incision and skin-grafting in his radical mastectomy technique. Deaton and Bradshaw (1953) also suspected wound infection. But they found no relation between

TABLE V.—Detailed Analysis

			Total No.	Cases of Swelling
Received radiotherapy to axilla	Radical mastectomy	Nodes cancerous	132	67 (51%)
		" clear	51	26 (51%)
	Local mastectomy	" not examined	28	3 (11%)
All cases with radiotherapy			211	96 (46%)
No radiotherapy to axilla			94	13 (14%)

arm-swelling and raised venous pressure, x-ray treatment, axillary metastases, arterial blood supply, or use of the arm. Wound infection and axillary scarring were the main factors in their opinion.

It is difficult to draw conclusions from this contradictory literature. But there seems to be no justification for denying that venous obstruction is a possible cause. This is not necessarily a direct result of axillary scarring, since Wyburn-Mason (1953) demonstrated the roles of costo-clavicular compression in four patients whose arm-swelling could be relieved by a sling support or excision of part of the first rib.

Post-operative and/or post-radiation scarring in the axilla is probably the most common factor, however, and the best conclusion from the present evidence is that of Aird (1955) that arm-swelling is "due either to the blockage of axillary lymphatics by malignant tissue, or to removal of the axillary lymphatic bottleneck in a radical amputation of the breast or to the fibrosis that follows high-dosage irradiation of the axilla."

Conclusion

This study has confirmed the clinical impression that arm-swelling often occurs after treatment for breast cancer. A morbidity rate of 36% can be expected when the method of treatment is radical mastectomy and post-operative radiotherapy, including the axilla. This is not to suggest replacing radical by local mastectomy, nor dispensing with x-ray treatment to the axilla. The survival rate is more important than the morbidity rate. But it might be rewarding to make a further study, as outlined above, to try to find out if a less radical mastectomy and a less severe axillary radiation reaction would be likely to reduce the morbidity due to arm-swelling without reducing the cancer survival rate.

Summary

Arm measurements were made of 305 unselected patients after routine treatment for breast cancer—a significant degree of arm-swelling was found in 36%. This morbidity rate is discussed.

Evidence was collected of the patient's subjective awareness of arm-swelling, and 55% complained of some inconvenience from this symptom. Significant swelling was found in 50% of patients whose axillary lymph nodes were involved with cancer, and in 28% of those which were not.

It was found in 46% of patients who had received x-ray treatment to the axilla and 14% who had not.

In 41% it was found after radical mastectomy, in 12% after local mastectomy.

There was no significant difference between left or right arm involvement.

The aetiology of arm-swelling is discussed.

I am grateful to the surgeons of the United Oxford Hospitals whose patients form the basis of this study. In particular, I thank Mr. A. Elliot-Smith, who has read this manuscript and made several helpful criticisms.

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"PREMATURE" CHILDREN AT PRIMARY SCHOOLS*

BY

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In an earlier paper (Douglas, 1956a) I described the mental test performances of 8-year-old children of low birth-weight. These "premature" children made consistently poor scores in both mental-ability and school-achievement tests when compared with a group of carefully matched controls. Their scores, unexpectedly, showed no clear relationship with either birth weight or length of gestation. Relatively high scores were made by those premature children born of mothers with a history of toxæmia or other abnormality during gestation, whereas the absence of such a history was associated with low scores. No adequate explanation could be given for these findings.

Further tests were given to the same groups of premature and control children when they were 11 years old, and the results of their 11+ secondary selection examinations are also known. In addition, their teachers have reported on their powers of concentration, discipline, and attitude to work. This new information is described in the present paper.

Background to this Study

A unique opportunity to make a controlled study of a representative group of premature children was provided by the Maternity Survey of 1946 (R.C.O.G. Survey, 1948). All children born during the first week of March of that year were enrolled in the inquiry, and among them were 706¹ legitimate single-born babies

*This inquiry is being made by a Joint Committee of the Institute of Child Health (University of London), the Society of Medical Officers of Health, and the Population Investigation Committee. The chairman of the Committee is Professor James Young, the vice-chairman Professor A. Moncrieff, and the secretary Professor D. V. Glass. The Nuffield Foundation has taken a major part in financing this work and grants have also been made by the Board of Governors of the Hospital for Sick Children, Great Ormond Street (through the Institute of Child Health), by the Ford Foundation, by the Population Council (Inc.), and by the Medical Research Council. Fourteen regional hospital boards have also made grants to the inquiry from their free moneys.

¹The number given in earlier papers was 707, but one child has since been excluded.