incidence of pulmonary embolism in hospital is one aspect of an epidemic of thrombotic disease at present affecting Western society.

REFERENCES

- Barker, N. W., Cromer, H. E., Hurn, M., and Waugh, J. M. (1945). *Surgery*, **17**, 207.
 Barritt, D. W., and Jordan, S. C. (1960). *Lancet*, **1**, 1309.
 Bauer, G. (1946). *J. Amer. med. Ass.*, **131**, 196.
 Byrne, J. J. (1960). *Ibid.*, **174**, 113.
 Coon, W. W., MacKenzie, J. W., and Hodgson, P. E. (1958). *Surg. Gynec. Obstet.*, **106**, 129.
 de Bakey, M. E. (1954). *Int. Abst. Surg.*, **98**, 1.
 Eskeland, G. (1962). *Lancet*, **1**, 1035.
 Gibbs, N. M. (1957). *Brit. J. Surg.*, **45**, 209.
 — (1959). *Ibid.*, **47**, 282.
 Harvey, W. P., and Finch, C. A. (1950). *New Engl. J. Med.*, **242**, 208.
 Henderson, E. F. (1927). *Arch. Surg.*, **15**, 231.
 Hermann, R. E., Davis, J. H., and Holden, W. D. (1961). *Amer. J. Surg.*, **102**, 19.
 Honey, G. E., and Truelove, S. C. (1957). *Lancet*, **1**, 1155.
 Lam, C. R., and Hooker, D. H. (1946). *Ann. Surg.*, **123**, 221.
 McLachlin, A. D., McLachlin, J. A., Jory, T. A., and Rawling, E. G. (1960). *Ibid.*, **152**, 678.
 Meister, H. (1960). *Frankfurt. Z. Path.*, **70**, 640.
 Ochsner, A., de Bakey, M. E., De Camp, P. T., and da Rocha, E. (1951). *Ann. Surg.*, **134**, 405.
 Payling Wright, H., and Osborn, S. B. (1952). *Brit. Heart J.*, **14**, 325.
 Seviitt, S., and Gallagher, N. G. (1959). *Lancet*, **2**, 981.
 Zeithofer, J., and Reiffenstahl, G. (1952). *Wein. klin. Wschr.*, **64**, 446.
 Zilliacus, H. (1946). *Acta med. scand.*, Suppl. No. 171, p. 1.

CEREBRAL AND PERIPHERAL EMBOLI CAUSED BY CERVICAL RIBS

BY

H. S. SHUCKSMITH, T.D., M.B., B.Sc., F.R.C.S.

Surgeon, United Leeds Hospitals and St. James's Hospital, Leeds

Lewis and Pickering (1934), Flint (1937), and Eden (1939) demonstrated that when a cervical rib or abnormal first rib produces complications it does so by direct damage to the third part of the subclavian artery, with subsequent thrombosis. Compression of the artery between the rib and scalenus anterior causes stenosis of the vessel with a post-stenotic dilatation, and the dilated part made prominent by the rib may be damaged by movements of the clavicle. Emboli may break off from the thrombus. Small emboli lodged peripherally cause minimal disturbance. Large emboli lodged in the brachial artery may induce further thrombosis and blockage of the axillary artery, which jeopardizes the fingers, but when the thrombus extends proximal to the damaged third part of the subclavian artery not only are paralysis of the hand muscles and gangrene of the fingers certain but cerebral embolism may also occur.

The common clinical picture of the effects of peripheral emboli is well documented (Rob and Standeven, 1958), but descriptions of cerebral emboli caused by cervical ribs are rare. Thrombosis in the subclavian artery proximal to the site of damage by a cervical rib, causing hemiplegia, was recorded by Symonds (1927) and by Hoobler (1942). Hoobler noted that Gould had recorded an instance in 1884; that Smith in 1941 had described the necropsy findings in a patient whose death had been caused by a cerebral embolus arising from a saccular aneurysm of the right axillary artery, which had blocked the right internal carotid; and that Yates and Guest in 1928 had described the necropsy findings in a patient having a thrombus in the right subclavian artery due to an un-united fracture of the clavicle and an embolus at the division of the basilar artery, which had travelled up the vertebral artery. A further example is described here. So long as the damaged subclavian artery is left *in situ* the patient must be at risk and the injured vessel must be treated as described by Schein *et al.* (1956), Wickham and Martin (1962), and Eastcott (1962).

Case 1

A girl aged 19 (1960) had felt pain in the right shoulder region two years previously and for two months had experienced coldness and numbness of the right hand and forearm, and eventually she lost the use of the limb. A right cervical rib was palpable, pulsation in the subclavian artery was increased and a systolic murmur was present over it, the radial and brachial pulses were impalpable, and the right hand

was cool. The blood-pressure in the left arm was 120/80 mm. Hg.

An arteriogram (Fig. 1) showed the subclavian artery arching over a cervical rib and for 3 cm. from this point filling was poor; the axillary artery was of normal calibre, but there was no filling beyond the junction of the upper and middle thirds of the brachial artery.

The scalenus anterior was divided, the distal part of the cervical rib was excised, and the first and second thoracic ganglia were removed, but the subclavian artery (dilated for 2-3 cm. from the level of the inner border of the cervical rib) was left alone. The radial pulse was restored and full function regained. The blood-pressure in each arm was 120/80.

FIG. 1.—Case 1. Arteriogram. The arrow points to site of block.

Case 2

In 1962 a girl aged 17 had for five months experienced tingling in all the finger-tips of the right hand (particularly in the index and middle fingers) and attacks of pain with pallor of the whole hand in cold weather. An unhealed paronychia on the right middle finger had been present for three months. There was general swelling of the right hand, particularly of the index finger, the tip of which was gangrenous; the hand was erythrocyanotic. The right subclavian, brachial, and radial pulses were impalpable. The blood-pressure in the left arm was 120/80. A radiograph showed bilateral cervical ribs. Some days later, after running for a bus, the patient felt dizzy and faint for a few minutes, and in an hour she experienced weakness of the left arm and leg, which recovered; a few hours later, however, weakness of the left face, arm, and leg reappeared and persisted. There was no loss of consciousness. The distribution of the paralysis pointed to a lesion in the

territory of the right middle cerebral artery, thought to be from an embolus which had originated in the right subclavian artery and lodged in the middle cerebral artery. This diagnosis was confirmed by Dr. Hugh Garland, who, although he had not previously seen the association, remembered being told of the syndrome by Dr. C. P. Symonds in 1929; and Garland and Phillips (1953) stated "Rarely the subclavian artery may be thrombosed, and retrograde thrombosis into the carotid results in hemiplegia on the opposite side of the body."

An arteriogram (Fig. 2) showed the right subclavian artery completely blocked from a point just beyond the origin of the thyrocervical branch, and it was probable that a thrombus

FIG. 2.—Case 2 Arteriogram. The arrow indicates site of block

extended along the lower border of the proximal part of the subclavian artery as far as the innominate artery. The origin of the vertebral and common carotid arteries appeared normal.

Operation was undertaken on the fourth day after development of the hemiplegia. The dilatation of the subclavian artery, extending from the inner border of the cervical rib for at least 4–5 cm. distally, was found to be completely blocked. A thrombus 1.5 cm. in length, with the proximal end a narrowing tail (Fig. 3), was removed from the subclavian artery at its origin. The subclavian artery was divided just proximal to the aneurysm, and after free bleeding from the proximal end the divided artery was sutured. The accessible part of the dilated subclavian artery was excised. No bleeding from the distal end occurred. The articulation of the cervical rib with the first rib, together with a part of the first rib, was nibbled away; the first and second thoracic ganglia were removed.

Recovery from the left hemiplegia was complete in 21 days; slight drooping of the right eyelid was evident for two months, and may have been caused by the ganglionectomy or by dissection of the ansa subclavia. Swelling of the right hand slowly resolved and small black areas developed on the pulp of all fingers and the thumb. Separation of the gangrenous ends of all the digits just proximal to the nail-bed was very slow, and complete paralysis of the muscles of the thumb

FIG. 3.—Case 2. Resected dilated subclavian artery filled with thrombus, and separate thrombus from first part of subclavian artery.

supplied by the median nerve persisted. The damage to the fingers and hand is permanent.

Case 3

A woman aged 43 (1957) had noticed numbness and blueness of the left hand and forearm and a pulsating swelling above the left clavicle 11 years earlier, when a thick tendinous scalenus anterior was divided, the distal part of a cervical rib was removed, and two months later an upper dorsal sympathectomy was carried out, with incomplete relief of symptoms. Embolic block at the bifurcation of the left brachial artery occurred in 1957 and a similar block a few months later.

Excision of the dilated subclavian artery in 1958 brought permanent relief.

Case 4

A woman aged 37 (1962) had no disability until she hurt her left hand in saving herself from falling when a bus braked suddenly. Almost immediately afterwards she felt an aching pain in the left wrist spreading up the forearm to the elbow, and a day or two afterwards she was unable to use the left hand. Attacks of pallor with paraesthesiae and later cyanosis of all four fingers of the left hand occurred; the thumb was not affected.

Five weeks after the accident the left hand was slightly cyanosed, and linear ecchymoses, which had never been larger, were present under the distal eighth of each finger-nail; the radial and brachial pulses were not palpable, and there was no increased pulsation in the subclavian artery. The blood-pressure in the right arm was 140/90. A large bony boss was palpable just above the mid-clavicle.

Radiography showed a complete left cervical rib, and from an arteriogram it was found that the left subclavian artery was obliterated from the level of origin of the thyrocervical branch of the first part of the subclavian artery to the level of the cervical rib. After the scalenus anterior had been divided, dilatation of the subclavian artery, which did not pulsate, was found to extend laterally from the inner border of the cervical rib. The proximal part of the dilated artery was excised and thrombus in the second part of the subclavian artery measuring 2.5 by 0.6 cm. was removed. Good bleeding was seen from each end of the divided artery. The distal end of the cervical rib and part of the first rib were removed and the first and second thoracic ganglia were excised. Convalescence was uneventful; the left hand became warm, free from pain, and had full power.

It should be noted that a thrombus was found in the second part of the subclavian artery and none in the axillary.

Case 5

In 1962 a woman aged 43 had experienced attacks of pain in the hand and pallor and, later, cyanosis of the fingers of the left hand. Originally only the index finger was affected, then the tips of all fingers, and later the major part of the fingers and the thumb. Finally, persistent pain from the wrists to the elbows interfered with work and sleep.

The fingers of the left hand were slightly cyanosed, the radial pulse was palpable but of smaller amplitude than the left, and the blood-pressure in the right arm was 140/85 and in the left 160/80. A bony left cervical rib could be felt and over it a murmur was heard from the subclavian artery.

Radiographs showed bilateral cervical ribs, the left being attached to the first rib. The scalenus anterior was divided and a dilated third part of the left subclavian artery was opened, to show a patch of densely adherent thrombus on the posterior-inferior wall but no free thrombus (Fig. 4). Bleeding from each end of the arteriotomy was free. The adherent thrombus was removed with the underlying intima, a narrow longitudinal strip of artery wall was excised, the arteriotomy was sutured, and the distal end of the cervical rib and part of the first rib and the first and second thoracic ganglia were removed.

Convalescence was uneventful. The hand and radial pulse were normal in September, 1962, but a thrill and murmur were still present over the subclavian artery.

FIG. 4.—Case 5. Dilated artery opened, showing the rough thickened intima on the lower posterior wall. The arrow points to the third innuma.

Case 6

A man aged 62 (1959) had known for many years that his left radial pulse was not palpable, but had never had any symptoms until three weeks before examination, when pain had started down the left arm and forearm, together with numbness, paraesthesia, and loss of the finer sensations in the hand. The left subclavian artery showed an increased pulsation and a thrill, the brachial pulse was impalpable, and the forearm and hand were erythrocyanotic and cool. The blood-pressure in the right arm was 170/100. Radiography showed an abnormal left first rib which articulated with the second rib and caused elevation of the thoracic outlet.

Symptoms subsided without treatment, but, although he was symptomless, three years later operation was advised. After the scalenus anterior had been divided the artery proximal to the dilatation was explored for thrombus, which was not present, and then the artery was ligated in continuity and the first and second thoracic ganglia were removed.

Convalescence was uneventful except that the sympathectomy produced pain in the shoulder for some weeks.

Discussion

Clinical evidence of increased pulsation in the third part of the subclavian artery establishes that the cervical rib is the causal agent and no special investigation is necessary. Arteriography is essential to establish the diagnosis when the subclavian artery has been blocked by thrombus, because similar ischaemic changes in the limb can be caused by an atherosclerotic block of the first part of the subclavian artery (Shucksmith, 1959).

Symptoms caused by small emboli may spontaneously resolve (Case 6), but so long as the damaged artery remains patent further emboli may be lodged months as in Case 2 or years as in Cases 3 and 6 after the first symptoms. Thrombosis proximal to an embolus lodged in the brachial artery may interfere with the collateral circulation to such an extent that gangrene of the hand will result, but the thrombosis may extend to the origins of the branches of the subclavian artery and on the right side to the carotid artery, causing a cerebral embolus (Case 2). Thus a cervical rib may produce minor symptoms in the hand which regress or remain little more than a nuisance for years, or a useless hand and a stroke may occur.

The natural history of a patient with a distal small embolus may be such that scalenectomy, incomplete

removal of the rib, and sympathectomy give relief of symptoms and restore a radial pulse (Case 1), but such procedures do not influence the dilatation of the artery and therefore do not prevent further embolic episodes (Case 3). Operative treatment must leave the patient safe from further embolic episodes and if the dilated artery is blocked an attempt must be made to restore blood flow in the axillary and brachial arteries, otherwise loss of use of the hand will be permanent (Case 2). Excision of the dilated artery was effective in Case 3. Ligation proximal to the aneurysm did not cause any complications (Case 6). A slice of artery was removed from one edge of the arteriotomy wound (Case 5) to narrow the dilated artery, but probably a wider piece ought to have been removed, because two months later a murmur was present over the artery. Possibly arterectomy and end-to-end anastomosis as carried out by Eastcott (1962) is the best procedure, but useful results have been obtained by Wickham and Martin (1962), who substituted a graft.

The artery proximal to the damaged artery (Case 4) contained thrombus even though there was free bleeding from the axillary artery. It would seem wise to explore the second part of the subclavian artery, because with palpation alone one cannot be certain that an artery is free from clot. When the dilated subclavian artery and the axillary and brachial arteries are blocked arterectomy and gangliectomy (Case 2) are useless in restoring the blood-supply of a severely ischaemic hand. Eastcott (1962) has reported success in such circumstances by sucking out clot from the axillary artery and boring out the proximal subclavian artery, and it would seem that an attempt on these lines should be made: expose the subclavian and axillary arteries, carry out thromboendarterectomy, and be ready to graft if a gap after excision of the dilated subclavian artery has to be bridged.

Summary

Six examples of damage to the subclavian artery from a cervical rib are described.

The clinical course in a young girl with gross ischaemia of the right hand and a left hemiplegia caused by a cervical rib is described; a damaged subclavian artery may cause disablement from proximal as well as from distal emboli.

Once the artery is damaged by a cervical rib the dilatation persists even though the rib is removed and the scalenus anterior is divided. Emboli can be prevented only by removing, plicating, or replacing the damaged artery, and such procedures are considered to be essential.

Gross ischaemic changes in the hand will be permanent once the dilated artery is blocked by thrombus unless the block in the subclavian and axillary arteries is removed.

I am indebted to Dr. P. G. Keates for the arteriograms and to Mr. A. Pegg, department of clinical photography, United Leeds Hospitals, for the photographs.

REFERENCES

- Eastcott, H. H. G. (1962). *Lancet*, **2**, 1243.
- Eden, K. C. (1939). *Brit. J. Surg.*, **27**, 111.
- Flint, E. R. (1937). *Ibid.*, **24**, 622.
- Garland, H. G., and Phillips, W. (1953). *Medicine*, p. 146. Macmillan, London.
- Hoobler, S. W. (1942). *New Engl. J. Med.*, **226**, 942.
- Lewis, T., and Pickering, G. W. (1934). *Clin. Sci.*, **1**, 327.
- Rob, C. G., and Standeven, A. (1958). *Brit. med. J.*, **2**, 709.
- Schein, C. J., Haimovici, H., and Young, H. (1956). *Surgery*, **40**, 429.
- Shucksmith, H. S. (1959). *Brit. med. J.*, **2**, 734.
- Symonds, C. P. (1927). *Brain*, **50**, 259.
- Wickham, J. E. A., and Martin, P. (1962). *Brit. J. Surg.*, **50**, 205.