Tumours <5 cm in diameter and at the anal margin have a more favourable prognosis.

Prognosis

For prognostic purposes most information of clinical value is obtained by distinguishing tumours arising at the anal margin from those in the anal canal and separating them into those greater or less than 5 cm in diameter. The tumour is relatively uncommon so there have been relatively few large follow up studies, but the five year survival rate is about 50%.

The photographs were prepared by the department of medical illustration, Christie Hospital and Holt Radium Institute. The full anal UKCCR trial protocol is available from the CRC Clinical Trial Centre, Rayne Institute, London.

Mr D J Jones is lecturer and honorary senior registrar, department of surgery, Hope Hospital, Salford, and Dr R D James is consultant radiotherapist, Christie Hospital and Holt Radium Institute, Manchester.

The ABC of Colorectal Diseases has been edited by Mr D J Jones and Professor M H Irving, Hope Hospital, Salford.

Lesson of the Week

Venous air embolism associated with removal of central venous catheter

Peter Mennim, Cormac F Coyle, John D Taylor

Air embolism may occur not only when inserting and manipulating central venous catheters but also when removing them.

The need to avoid air embolism when inserting and manipulating central venous catheters is widely appreciated but the risk after catheter removal is less widely known. This has implications regarding the delegation of practical procedures.¹

Case report

A 73 year old man was admitted for elective repair of an 8 cm abdominal aortic aneurysm. The past history included a myocardial infarction complicated by ventricular fibrillation eight years previously and an episode of acute left ventricular failure one year before when mitral incompetence was noted. The preoperative echocardiogram showed minimal mitral regurgitation and an ejection fraction of 54%. The aneurysm repair was uneventful, lasting 90 minutes. An episode of pulmonary oedema on the first day was easily treated with diuretics and oxygen. Thereafter, he had an uneventful course, returning from the intensive care unit to the ward on the second postoperative day.

A pulmonary flotation catheter (7.5 French gauge) had been inserted into the right internal jugular vein at the time of operation and the catheter sheath was removed by the houseman on the fifth day. About two minutes later the patient collapsed and became unresponsive with no palpable cardiac output. Cardiac massage was begun. On arrival the arrest team noted a spontaneous respiration rate of 18/min with good ventilatory efforts. Pulse was 120/min, regular, and in sinus rhythm. Blood pressure was 90/60 mm Hg and there was good colour and no cyanosis. The patient was sweating profusely. He was unresponsive to painful stimuli. Pupils were of normal size and reacting symmetrically. There were no focal neurological signs. Chest sounds were normal but examination of the heart disclosed widespread loud, harsh, crunching sounds throughout systole and diastole over the whole precordium. The originally recorded murmur of mitral incompetence could not be heard.

Examination of abdomen and legs showed nothing abnormal apart from the recent incision. Blood glucose concentration was 6.7 mmol/l, and haemoglobin and

Prevention

Central venous catheters must be removed with the patient supine or in slight Trendelenburg position and the entry site covered by an air occlusive dressing. A satisfactory choice is a transparent semipermeable dressing like Tegaderm.⁷ Alternatively, a gauze dressing may be used with firm manual pressure, and once haemostasis is achieved an air occlusive dressing substituted. A gauze dressing is not air occlusive unless completely covered by tape, as illustrated by two instances of venous air embolism with sitting up some 10-15 minutes after catheter removal.⁶ A definitive length of time for keeping the dressing has not been determined, but intervals of 24-72 hours have been suggested.

Treatment

Successful treatment of venous air embolism relies on rapid recognition and prompt action. Further air entry must be stopped. The patient should immediately be placed in a head down, left lateral position, allowing blood to pass through the inferiorly located pulmonary outflow tract. Lowering the head may also decrease the risk of paradoxical air embolism to the brain through a patent foramen ovale. The patient should breathe 100% oxygen to promote reabsorption of nitrogen from the pulmonary circulation. If cardiac arrest occurs, then external cardiac massage may move the air embolus into the pulmonary vasculature, where capacitance is greater, thereby relieving the obstruction to right ventricular outflow. If a central venous catheter is in place, then aspiration of air should be attempted. Thoracotomy and open chest cardiac massage followed by aspiration of air directly from the right ventricle has been successful in isolated cases of massive air embolism. Hyperbaric oxygen may be of benefit. If these manoeuvres fail emergency cardiopulmonary bypass has been advocated.

electrolyte concentrations were normal. Blood gas values measured with the patient breathing 35% oxygen were oxygen tension 18.4 kPa, pressure of carbon dioxide 5.2 kPa, pH 7.27, standard bicarbonate concentration 17.6 mmol/l, and base excess -8.4 mmol/l. The electrocardiogram showed sinus

Leighton Hospital, Crewe
CW1 4QJ
Peter Mennim, senior medical
house officer
Cormac F Coyle, medical
registrar
John D Taylor, surgical
registrar

Correspondence to:
Mr J D Taylor, Transplant
Unit, Royal Liverpool
University Hospital,
Liverpool L7 8XP.

BMJ 1992;305:171-2

tachycardia, old anterior myocardial infarction, and no signs of acute right or left heart strain. A supine chest radiograph showed no changes in the lung fields, and the heart and mediastinum looked normal. The patient recovered fully within 30 minutes and examination showed no abnormality apart from a mitral incompetence murmur. In particular, the previously noted crunching sounds had disappeared. The subsequent course was uneventful, and the patient was discharged 11 days after operation.

The acute event was diagnosed as venous air embolism. The catheter had been removed with the patient sitting at 45 degrees and the exit site dressed with a cotton wool ball affixed by Micropore tape. Active management had been to place the patient in the left lateral position, give oxygen, and, most important, seal the entry wound, preventing further air entry.

Discussion

Venous air embolism is a significant complication of central venous catheters. A literature review identified 79 cases of air embolism, 25 of which were fatal, and four occurred after catheter removal.² Unfortunately, some survivors have residual neurological deficit due to cerebral hypoxia. Fibrin tracts consistently form around catheters, sometimes within 24 hours of insertion, creating a potential portal for venous air entry after catheter removal.³ The tract of a long term catheter is likely to seal more slowly, though air embolism has been reported after removal of catheters in place for only three days. Removal in an upright position increases the risk by reducing intrathoracic pressure. The increasing use of large bore sheaths for pulmonary flotation catheters also increases the risk of air entrainment during their removal.⁴ Coughing may separate soft tissues along the catheter tract, and forceful inspiration immediately after a cough may facilitate the entry of air. The exact lethal volume of air is unknown, but it is suggested that air entry at 20 ml/s will produce symptoms whereas 75-100 ml/s may be fatal. Air can enter the central circulation at a rate of 100 ml/s through a 14 gauge cannula.⁵ Much greater quantities of air may be tolerated in the supine position as air can collect in the right ventricular apex away from the pulmonary valve.

Air embolism is characterised by the sudden onset of respiratory distress, commonly associated with cardiac and neurological deficit. Symptoms and signs reportedly include dyspnoea, wheeze, cyanosis,

tachypnoea, chest pain, cardiovascular collapse, neurological deficits, seizure, and coma. A wide variety of heart sounds have been described with venous air embolism, but it is the churning "mill wheel" murmur that is most frequently described, though this murmur is a late occurrence, transient, and dependent on a large amount of air being present in the right ventricle and pulmonary outflow tract. The diagnosis frequently depends on association of a clinical catastrophe with a disconnected catheter or other cause of air entry. Investigations are rarely helpful in the acute setting. The electrocardiogram may show ischaemia, bradycardia, conduction disturbance and right heart strain. Air and blood levels have been reported in chest radiographs but generally require an erect film. Air has been seen in computed tomograms of the brain shortly after the onset of neurological changes. Perfusion lung scans are abnormal during the acute event but return to normal in survivors after about 48 hours.

We surveyed the practice of venous catheter removal in two hospitals. Eleven of 12 house officers questioned had removed a catheter unsupervised the first time. Only five had received verbal instruction in the proper method. Six had the patient semi-erect, the method that three had been instructed in. Three were aware of the risk of air embolism and specified an air occlusive dressing, but the remainder used gauze. Of the nine nurses questioned, all adopted the supine position for removal, six specified an air occlusive dressing, and the remainder used gauze. This survey indicates a lack of awareness among junior doctors of this serious but entirely preventable complication associated with central venous catheters. Written nursing procedures emphasise the importance of preventing air embolism when caring for and removing central venous catheters, which may explain their greater awareness in our survey.⁷

- 1 Dyer C. Manslaughter convictions for making mistakes. The real lessons are for training and supervision. *BMJ* 1991;303:1218.
- 2 Seidelin PH, Stolarek IH, Thompson AM. Central venous catheterisation and fatal air embolism. *Br J Hosp Med* 1987;38:438-9.
- 3 Hosal VL, Aulsebrook RG, Hoskins PA. Fibrin sleeve formation on indwelling subclavian central venous catheters. *Arch Surg* 1971;102:353-8.
- 4 Mendieta JM, Roy TM, Denny DM, Ossorio M. Venous air embolism associated with removal of central venous catheter. *J Ky Med Assoc* 1988;86:169-73.
- 5 Flanagan JP, Gradisar IA, Gross RJ, Kelly TR. Air embolus; a lethal complication of subclavian venipuncture. *N Engl J Med* 1969;281:488-9.
- 6 Turnage WS, Harper JV. Venous air embolism occurring after removal of a central venous catheter. *Anesth Analg* 1991;72:559-60.
- 7 Thielens JB, Nyquist J. Subclavian catheter removal. *Journal of Intravenous Nursing* 1991;14:114-8.

(Accepted 8 June 1992)

ONE HUNDRED YEARS AGO

Belvoir Castle and Denton Manor. — It would not be easy to name an excursion at any recent meeting of the Association which has given more unalloyed pleasure to those who joined it than did this. The expedition started from Nottingham by special train on the Great Northern Railway on Saturday morning, in dull weather, which, however, improved as the day went on, and after midday was of the finest—warm and cloudless. On arrival at Stathern, carriages were in attendance to convey the party through the woods to Belvoir. The mausoleum, chapel, armoury, and magnificent State apartments of the castle were visited, whilst the far-famed collection of pictures, busts, and tapestry was minutely inspected. The views from the different rooms and castle walls were much admired. His Grace the Duke of Rutland most hospitably entertained the company at luncheon in the noble dining-room of the Castle, the Hon. Mr. Scott, agent to his Grace, occupying the chair. Dr. C. J. Hare, on behalf of those present, proposed a very hearty vote of thanks to the Duke and Duchess, for their hospitality, and took occasion to remark that the kindness with which the members of the Association had been received and entertained in

Nottingham and its vicinity during the week could not have been surpassed. The Hon. Mr. Scott, in replying, read a telegram from the Duchess, deploring that her Grace and the Duke were unfortunately detained in London, and so could not personally receive their guests. The health of the Duke and Duchess, and that of the Hon. Mr. Scott, was drunk with enthusiasm. The company then separated into various parties, which, under the guidance of Mr. Shipman, of Grantham, medical attendant to the Duke, Ingram, the gardener, and Mr. Marvel, inspected the gardens, which are sheltered by surrounding hills, and are of the widest extent. Assembling at the kennels at 3.30 P.M. the visitors were received by Frank Gillard, the Belvoir huntsman, who exhibited two packs of fox hounds. In perfect sunshine the party next drove to Denton Manor, where Sir William and Lady Welby and members of their family most kindly received and entertained the guests at tea. The house and its valuable artistic contents, the grounds, and the adjacent church, were all minutely inspected. A drive to Grantham, where the party separated, concluded this most enjoyable excursion. (*BMJ* 1892;ii:312)