particular, it is important to obtain a complete history of the onset of the attack and an exact description of the patient's behaviour during it, since afterwards, whatever the cause, there will usually be no abnormalities and the patient will be unable to recollect what has occurred. Nonetheless, differentiation of transient global amnesia and amnesia due to temporal lobe epilepsy may present difficulties even when there is a good account of the attack, and it is in these cases that an E.E.G. recorded as soon as possible after an attack is helpful. No other investigation is likely to yield diagnostic information.

Finally, there are other possible causes of transient amnesia in addition to those illustrated by our cases. Hypoglycaemia should always be excluded. Alcoholism may present as an "alcoholic blackout"[23] and the acute amnesia of Korsakoff's syndrome should be easily recognized by its association with alcoholism or malnutrition, by the confusional or confabulatory state, by the patient's lack of awareness of his memory disorder, and by the presence of perpheral neuropathy or of ocular signs, indicating Wernicke's encephalopathy. An acute, partially reversible amnesia may be a manifestation of clioquinol poisoning,[24] and we have seen a patient who was amnesic for 48 hours during an allergic encephalopathy due to antitetanus serum. Transient amnesia might be expected to occur as an epileptic event in patients with temporal lobe tumours, but we have not encountered this[25] and it must be uncommon, perhaps because in such patients the functional disturbance is limited to one temporal lobe.

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Occasional Survey

Four Years' Experience with Indwelling Silastic Cannulae for Long-Term Peritoneal Dialysis

M. R. HEAL, A. G. ENGLAND, H. J. GOLDSMITH

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Summary

Indwelling silicone rubber cannulae have been used for peritoneal dialysis in 41 uraemic patients for periods of up to 46 months. The simplicity of this treatment is particularly suited to patients awaiting transplantation.

Introduction

The difficulty in maintaining safe, comfortable, and long-term access to the peritoneal cavity has been one of the main problems in the management of patients with chronic renal failure by peritoneal dialysis. The Trocath peritoneal catheter designed for short-term dialysis (McGaw, Charles F. Thackray, Leeds) is unsuitable for repeated use as it is uncomfortable and soon becomes loose in its track with resultant fluid leakage, infection, and peritonitis. Moreover, the mobility of a patient with such a catheter is limited.

To overcome these difficulties multiple puncture techniques have been used with some success, but often have had to be abandoned because of the state of depression related to the discomfort of the treatment.[1] This method increases the chances of eventually puncturing a viscus or important blood vessel and cannot be used unaided by the patient. Peritoneal access with puncturable transcutaneous devices[2 3] or plastic prostheses to maintain a fibrous track between the skin and peritoneum[4 5] have been unsatisfactory in the long term because of leakage of fluid and infection.

The use of a long subcutaneous silicone rubber tube was suggested by Palmer *et al.*,[6] but in our hands this soon moved freely in its track with the development of subcutaneous abscesses. A similar tube with an expanded silicone area in its middle third which was inserted into the rectus sheath was also unsatisfactory. Two such cannulae disappeared subcutaneously and required operative removal.

A more successful cannula was developed on our unit.[7] This consisted of a perforated silicone rubber tube with a short Dacron collar which was inserted through an existing sinus track and fixed to the skin by an external reinforcing silastic flange. Though this functioned satisfactorily for periods up to 10 months it was difficult to insert, tended to extrude, and the skin under the flange became macerated.

Liverpool Regional Urological Centre, Sefton General Hospital, Liverpool L15 2HE
M. R. HEAL, F.R.C.S., Research Fellow and Senior Registrar in Urology
A. G. ENGLAND, M.B., CH.B., Research Fellow, Renal Unit
H. J. GOLDSMITH, F.R.C.P., Consultant Physician

Tenckhoff and Schechter[8] described an indwelling cannula with a long subcutaneous section anchored by Dacron collars both at the point of entry to the peritoneal cavity and under the skin exit. Their results were encouraging and at the start of our work they had successfully used such a cannula for 14 months. We inserted two of these cannulae, but thought that their technique of insertion was too complicated to be used as a bedside procedure. Moreover, elective removal of the catheter proved difficult.

New Type of Cannula

A simple silicone rubber tube with a Dacron flange has been developed and used by us for periods of up to 19 months but it had a tendency to be slowly extruded despite the ingrowth of fibrous tissue into the Dacron. For this reason we now use a tube with a flange and cuff (Fig. 1).

PREPARATION OF CANNULA

The cannula is made from a 35-cm length of medical grade silicone rubber tubing (Silastic, Lepetit Pharmaceuticals, Ltd., Maidenhead, Berks, measuring 0·192 in (4·9 mm) outside diameter and 0·104 in (2·6 mm) inside diameter. After degreasing with acetone a cylindrical cuff of Dacron Velour (Down Bros. and Mayer and Phelps, Ltd., Mitcham, Surrey, ref. No. 6108) 2 cm long and 0·9 mm thick is stuck to the tubing 18 cm from the distal end with Silastic medical adhesive type A (fig. 1). The complete cannula can now be obtained from Sterimed Ltd., Bootle, Lancs. L30 4UZ.

This cuff is held in position while setting by means of an arterial forceps. A circular collar of Dacron 1·5 cm in diameter is bonded to the cuff proximally at an angle of 30° to the long axis of the cannula with a thin layer of the same adhesive, which takes 24 hours to set at room temperature (fig. 2). The terminal 12 cm of tube is then perforated with four equispaced rows of 0·9 mm holes at 0·5 cm intervals. (A 19 G needle, the end of which is cut square and sharpened, makes a convenient punch for this purpose. This is attached to a syringe for ease of handling.) Before use the cannula is washed carefully in clean water to remove any dirt and dust. It is then rinsed in distilled water, packed in a lint-free container, and autoclaved.

TECHNIQUE OF INSERTION

This is a bedside procedure which normally takes about 30 minutes. First the patient's bladder is emptied, if necessary, by catheter. Full aseptic precautions are essential; the operator wears mask, gown and gloves, and the patient's abdomen should be surgically prepared and towelled, as for laparotomy. The preferred position is in the midline 3 cm below the umbilicus

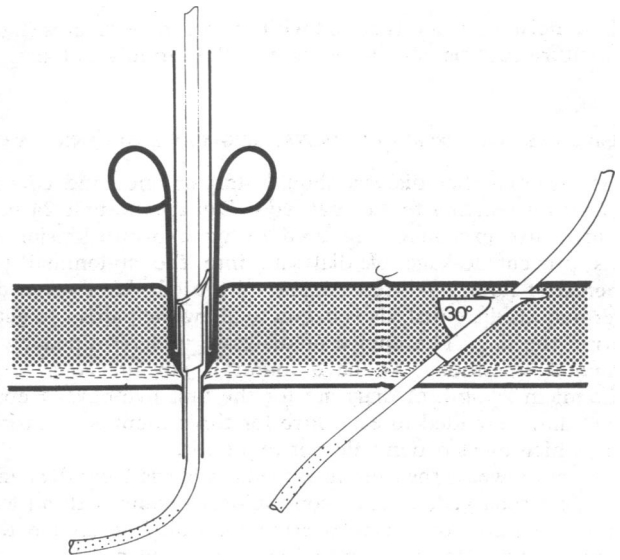

FIG. 2—Technique of insertion. Note that flange lies parallel to skin and clear of original insertion site.

but a lower or flank position may be used if the former is not a virgin site. After infiltrating the subcutaneous tissues with local anaesthetic the abdomen is prefilled with 2 litres of warm dialysate to which 2,000 units of heparin has been added.

Insertion is greatly helped by using the Tenckhoff[9] trocar (Cobe Laboratories, Lakewood, Colorado, U.S.A.) (fig. 1). If this is not available any other suitable trocar may be used but if a tight fit is not obtained between the cannula and the peritoneum fluid will leak into the anterior abdominal wall. A 3-cm transverse incision is made and a space large enough to take the trocar is produced by blunt dissection of the subcutaneous tissues. It should be possible to feel the rectus sheath and linea alba with the fingertip. The trocar is pushed into the abdominal cavity by steady pressure. This is made easier if the patient tenses his abdominal muscles. The length of the intra-abdominal section of the cannula is trimmed so that it is judged that the tip will lie freely in the pelvis.

The cannula, stiffened by an obturator (that supplied with the McGaw trocath is suitable), is passed through the inserter and pushed posteriorly and inferiorly into the pelvis. If any resistance is felt the cannula must be withdrawn and re-positioned to avoid damaging bowel or mesentery. When a satisfactory position is obtained the inserter is removed leaving the cannula in situ. A syringe is attached to the cannula and if a free return flow is not obtained it must be re-positioned.

The extra-abdominal section of the cannula is brought out through a skin stab 3 cm superior to the first incision. The flange should lie beneath the exit point, deep to the skin and clear of the

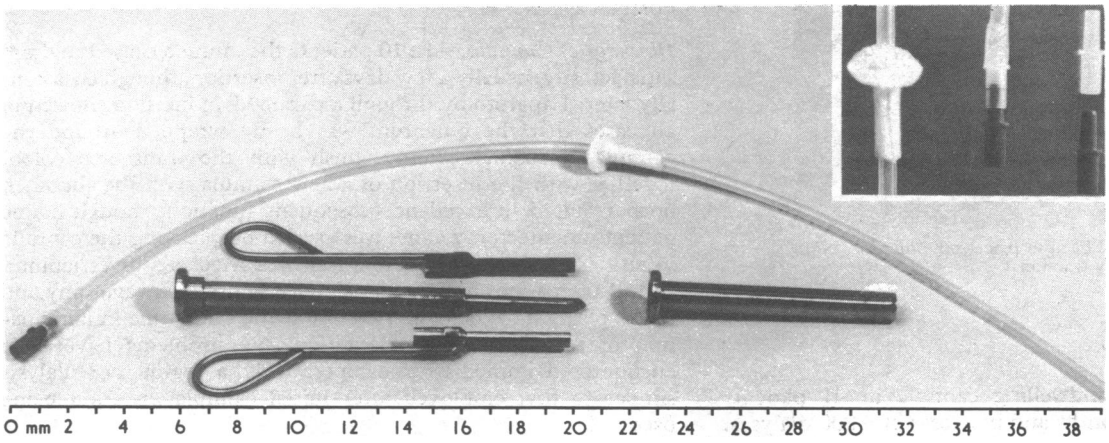

FIG. 1—Silastic cannula and Tenckhoff introducer. Insert shows Dacron cuff and flange and disposable plug and connector at end of cannula.

initial incision, which is closed with two or three sutures (fig. 2). No suture material should be used at the cannula exit site.

IMMEDIATE POSTINSERTION DIALYSIS REGIMEN AND CANNULA CARE

It is essential that dialysis should start at once and continue *without interruption* for several days. During the first 24 hours rapid ½-litre exchanges are used to avoid overdistension and thus prevent leakage of dialysate into the abdominal wall. Thereafter hourly 1-litre exchanges are used. After seven days overnight 20-litre dialysis is begun to allow the patient to get up during the day. The choice of dialysate is determined by the patient's condition. We have found it advantageous to use gentamicin 2 mg/l. of dialysate for the first five days. Heparin 1,000 units is added to each litre for three months of dialysis, after which most patients do not require it.

After two weeks the cannula is well established and the patient may be discharged, dialysis continuing at home with an automatic machine[10] or during overnight hospital admission three times weekly. Cannula care presents few problems, but a strict aseptic and antiseptic technique must be used whenever the cannula is handled. The outer end of the cannula has a plastic insert (Avon Medicals Ltd., Birmingham ref. No. R91) which is closed by means of a red plug (Avon ref. No. R94). The latter is renewed after each dialysis (fig. 1). Before the cannula is opened the outside of the tube and connexion are wiped with povidone iodine. Between dialysis the cannula is covered by a dry dressing and is interfered with as little as possible. Full immersion in a bath should be avoided, but low water bathing or showering is acceptable.

CANNULA REMOVAL

Elective removal of the cannula is carried out at the bedside but requires dissection as it cannot be withdrawn by traction alone (fig. 3).

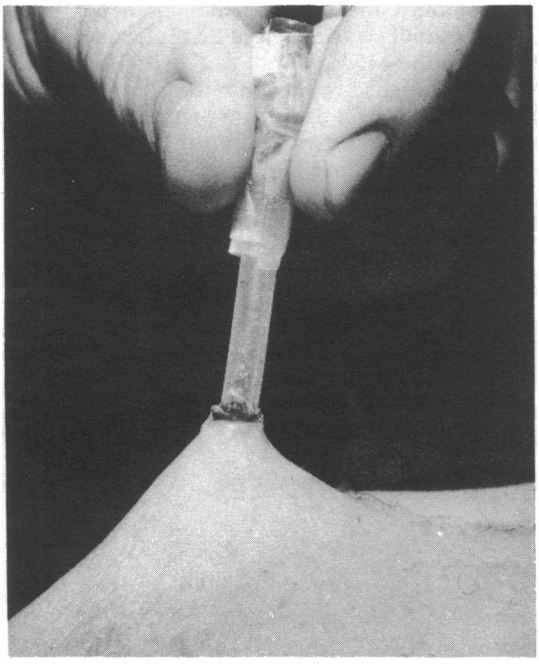

FIG. 3—Cannula that had been in place some months. Note that it is not displaced by traction.

Results

Our experience with the indwelling cannula in 41 patients extends over 300 patient months and in excess of 3,800 dialyses. We have treated 31 adults and five children with chronic renal failure, and five patients who received supportive dialysis by this method for periods of up to three months while undergoing elective surgery such as removal of bilateral renal calculi.

Of 25 patients treated without any complications for a total of 142 patient months eight have been transplanted while on peritoneal dialysis. Four are currently awaiting transplantation, and six have been electively transferred to haemodialysis (table I). Four patients on supportive therapy during surgical procedures had their cannulae removed after recovery. Treatment was stopped electively elsewhere on one patient who became Australia antigen positive. Two other patients died: one had acute renal failure from perforation and subsequent haemorrhage from a duodenal ulcer, and one committed suicide.

Sixteen cases in which cannula complications occurred are summarized in table II. Six patients were successfully maintained on peritoneal dialysis for at least a year or until they could be taken on to haemodialysis. One patient rejected two transplants during 46 months on peritoneal dialysis. Death directly attributable to peritonitis occurred in only two of the six patients who died in this group. Other complications are discussed more fully below.

Patients have usually found the cannula comfortable and easy to manage. They are fully mobile and have no fear of cannula displacement (fig. 3). Eight patients have been on automatic peritoneal dialysis at home, most of the remainder being treated as day or night-stay hospital patients. Most patients have been able to return to work or manage their housework. There has been no local haemorrhage.

TABLE I—*Summary of 25 Patients Without Cannula Complications on Peritoneal Dialysis*

Case No.	Months on Dialysis	Present Status	No. of Dialyses
1	18	Awaiting transplant	150
2	7	" "	110
3	9	" "	216
4	1	" "	12
5	13	Transfer to haemodialysis	310
6	14	" " "	60
7	5	" " "	40
8	5	" " "	40
9	5	" " "	60
10	2	" " "	16
11	10	Transplanted	240
12	6	"	60
13	4	"	30
14	4	"	40
15	4	"	40
16	3	"	30
17	5	"	125
18	4	"	80
19	13	Dead. Suicide	120
20	3	Treatment stopped. Australian antigen positive	12
21	3	Off dialysis (after bilateral pyelolithotomy)	2
22	2	" " " " "	2
23	1	" " (after prostatectomy) "	1
24	1	" " (acute renal failure)	1
25	1	Dead. Bleeding and perforated duodenal ulcer	1
Total	142		1,798

COMPLICATIONS

Blockage of Cannula.—In 10 patients the cannula ceased to drain satisfactorily, usually a few days after insertion, though occasionally later. Laparotomy through a paramedian incision showed in all cases that the omentum was firmly wrapped around the cannula. An omentectomy, flush with the transverse colon, together with the insertion of a new cannula with the abdomen open resulted in excellent subsequent function, though in one patient omentectomy alone was carried out, leaving the cannula in situ. Appendicectomy, removal of a Meckel's diverticulum, and, if the patient had duodenal ulcer symptoms, vagotomy and pyloroplasty have been carried out at the same time in anticipation of subsequent transplantation. No problems have been encountered immediatly postoperatively, a regimen of dialysis similar to that employed after initial cannula insertion being used.

TABLE II—*Summary of 16 Patients With Cannula Complications during Long-term Peritoneal Dialysis*

Case No.	Months on Dialysis	Present Status	Comments	No. of Dialyses
26	46	On home peritoneal dialysis	Initial cannula replaced because of slow extrusion. Two failed transplants	540
27	18	" " " "	Omentectomy. Track infection required cannula replacements	360
28	15	Transfer to haemodialysis	Peritonitis at 14 months. Omentectomy. Cannula replaced	180
29	13	" " "	Omentectomy soon after insertion. Then uneventful until peritonitis at one year	200
30	6	" " "	Peritonitis at six months	70
31	2	" " "	Leakage of fluid due to double peritoneal puncture	3
32	1	" " "	Persistent hypoproteinaemia	2
33	8	" " "	Child. Skin ulceration and peritonitis	64
34	7	" " "	Child. Peritonitis. Omentectomy	56
35	6	" " "	Child. Peritonitis at six months	48
36	15	Died. Pulmonary embolus	Peritonitis at 14 months. Omentectomy and cannula replaced	120
37	14	Died. Cerebrovascular accident	Omentectomy for poor drainage at 14 months. Subsequent good flow	220
38	8	Died. Peritonitis	Patient untrainable. Three cannulae replaced. Peritonitis on home dialysis	96
39	3	Died. Peritonitis	Peritonitis at initial insertion. Omentectomy at two months	12
40	8	Died. Acute heart failure	Child. Peritonitis and omentectomy	64
41	3	Treatment stopped. Unsuitable for transplant	Omentectomy. Pyloroplasty for duodenal ulcer at six weeks	5
Total	173			2,040

Peritonitis.—Though the triad of fever, abdominal tenderness or pain, and a turbid fluid effluent is almost diagnostic of bacterial peritonitis, antibiotic treatment was started on suspicion when any one of these appeared. Frank peritonitis occurred in 11 patients. This was treated by *continuous* dialysis with gentamicin 2 mg/l. of dialysate for 48 hours and then 1 mg/l. until the patient's symptoms improved and the effluent remained sterile. In four cases the infection was severe, leading to death in two. These deaths could be traced to definite breakdowns in sterile technique.

Track Infection.—Two early and one late track infections occurred, in one shortly after insertion and in one where an earlier model cannula was inserted through the track of a previous Trocath. In one patient the track infection was extensive and did not respond to conservative treatment. She eventually developed peritonitis, the same organism being cultured from the track and effluent. Though surgical drainage of the track may result in resolution, excision and insertion of a new cannula clear of the infected site is recommended. In two children ulceration of the skin overlying the cuff occurred.

Leakage of Fluid.—Only one patient leaked fluid into the subcutaneous tissues due to double puncture of the peritoneum at the time of cannula insertion. This low rate of leakage is attributed to the small peritoneal puncture obtainable with the Tenckhoff introducer.

Discussion

We believe that peritoneal dialysis through an indwelling silicone rubber catheter is a useful treatment for patients with chronic renal failure, but attention must be paid to detail for the technique to be a success. Elsewhere untrained junior staff are not allowed to supervise haemodialysis, but are often expected to conduct peritoneal dialysis with a resultant increase of infective complications, which discredits this therapy. On the other hand, it is an easy technique to teach and our patients are able to carry out their own dialysis after three weeks' tuition. Eight such patients have dialysed themselves at home.

Peritonitis is the major complication associated with peritoneal dialysis. Histological section of the cuff has shown an ingrowth of fibrous tissue into the Dacron after a short period. This forms an effective barrier to the spread of infection along the track of the cannula. We believe that haematogenous or enterogenous spread of bacteria into the dialysis fluid is rare, if it occurs at all, and that infection is due to the introduction of bacteria down the lumen of the cannula. Patients and nurses must be carefully instructed in a rigid aseptic technique which includes the wearing of masks and sterile gloves together with the cleaning of all connexions with iodine.

With this regimen the occurrence of peritonitis has been reduced to less than 0·3% of dialyses. Most patients can be kept fit until they can be transplanted or taken on to a regular haemodialysis programme even though this may take more than a year. If peritonitis occurs it can usually be successfully treated though omentectomy may be required.

Children with renal failure are a special problem as blood vessel access is difficult and they do not take kindly to repeated puncture techniques for peritoneal dialysis. In our experience tolerance of this treatment with an indwelling silicone rubber cannula has been excellent. As children have little subcutaneous tissue a small Dacron collar and cuff is essential. To avoid ulceration the flange should lie well clear of the initial skin incision and parallel to the skin surface (fig. 2). The omentum is finer in children and is likely to be drawn through the holes into the cannula. For this reason we are now considering omentectomy at the time of cannula insertion.

On the basis of animal experiments Mion[11] suggested that omentectomy increases the incidence of small bowel adhesions but we have found few or no adhesions in patients in whom inspection of the peritoneal cavity has been possible subsequent to omentectomy.

Possibly the use of large volumes of dialysing fluid is an important factor in maintaining access to the peritoneal cavity, and our patients usually exchange 20 litres during a 10-hour session at least three nights a week. Nevertheless, several cannulae have lain dormant for up to 10 weeks and functioned well thereafter.

Details of the patients' clinical condition and of automatic dialysing machinery will be published shortly.[10] However, we wish to state now that, though our patients have a slightly higher blood urea than those maintaned by haemodialysis, their well-being is comparable, and there have been no difficulties attributable to the dialysis in those that were transplanted.

It is estimated that 2,000 people die annually in this country who could benefit from haemodialysis or transplantation. Logistically it is impossible to maintain all these patients by haemodialysis, even if they were suitable. Though in some units early transplantation allows most patients to be treated, this cannot be attained universally and the present shortage of cadaveric kidneys inevitably means that many patients require a period of maintenance dialysis if their clinical condition is to be kept stable. The pool of patients awaiting cadaver renal transplantation could be materially increased if established haemodialysis units added medium-term maintenance peritoneal dialysis to their therapeutic repertoire. This will be generally recognized when the financial impediment to this form of treatment has been removed by the availability of automated peritoneal dialysis machines producing their own fluid.

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Medical History

One-Hundred-and-Fifty Years of Measurements of Hydrochloric Acid in Gastric Juice

J. H. BARON

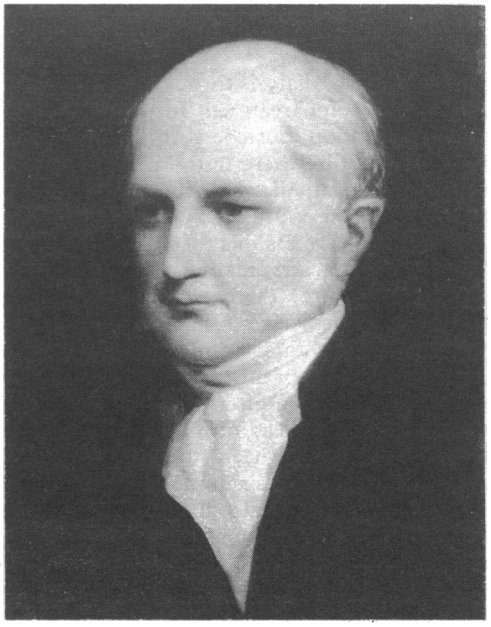
British Medical Journal, 1973, 4, 600–601

> "Were it more the custom in this country to bestow honours on those who devote their time, their talents, and their lives to benefit heir fellow-creatures, such researches as Dr. Prout's would not have passed unrecognized. But deeds in arms and in diplomatic arts, improvements in shells and rockets for the destruction of life, monopolise such distinctions, whilst the gratitude of the afflicted, with the good opinion of mankind, are the chief rewards to be looked forward to by the philanthropic physician."[1]

Life of William Prout

William Prout[1-5] was born on 15 January 1785 in Horton, a remote village in Gloucestershire where his family had been landed gentry for generations. He was educated locally until he was 13. At 17 he went to a clerical academy at Sherston for 18 months, and after a further period at home spent two years at another clerical academy in Bristol before going to Edinburgh in 1808 to study medicine. He was taught anatomy by Alex Monro *tertius*, chemistry by Thomas Charles Hope, and physiology by Andrew Duncan. After graduating in 1811 with a thesis on intermittent fevers he came to London to study at the Guy's of the surgeon Astley Cooper, the physicians Thomas Addison, Richard Bright, and Thomas Hodgkin, as well as the animal chemist Marcet, who discovered xanthine. Prout was admitted a Licentiate of the Royal College of Physicians of London in 1812 and devoted the rest of his life to research, lecturing, and writing on chemistry while earning his living as a clinician. In 1813 he moved to 4 Arundel Street, Strand, and began there his lectures on animal chemistry. In 1814 he married, visited Paris, took a house in Southampton Street, Bloomsbury, and set up in practice. The same year he was elected a Fellow of the Royal Medical and Chirurgical Society, and in 1819 became a Fellow of the Royal Society.

His practice grew slowly because of the prejudice of most physicians against chemical doctrines. In 1825 he moved to 40 Sackville Street, where he lived until his death in 1850. His consulting room was heaped with papers, letters, and chemical apparatus. He did his research in the morning, breakfasted at 7, and saw patients until 10 in the evening. Even after he became a leading London physician he never amassed the usual fortune because of his unbounded liberality regarding fees as well as his heavy expenditure on scientific equipment and research. He was al-



William Prout (1785–1850). Portrait by H. W. Phillips. (Reproduced by permission of the Royal College of Physicians of London.)

Department of Surgery, Royal Postgraduate Medical School, London W12 0HS
J. H. BARON, D.M., M.R.C.P., Lecturer and Consultant