CORRESPONDENCE

Correspondents are asked to be brief

Clean Air Operating Room Enclosures J. Charnley, F.R.C.S. 224	Effects of Posture on Limb Blood Flow in Late Pregnancy G. B. Drummond, M.B., and others 228	Cardiovascular Disease and Peptic Ulcer A. P. Barabas, F.R.C.S. 231
Deaths during Dentistry L. Milner, M.R.C.S., D.A. 225	How Significant is Persistent S-T Segment Depression? B. Livesley, M.R.C.P. 228	Understanding Blindness W. J. Dinning, F.R.C.S. 231
Respiratory Recording from the Oesophagus J. S. Robinson, F.F.A. R.C.S. 225	Skin Reactions to Practolol Constance M. Ridley, F.R.C.P. 229	Vitamin D and Myocardial Infarction F. Eskin, M.F.C.M. 232
Comparison between Free Thyroxine Index and effective Thyroxine Ratio F. Clark, F.R.C.P., and D. B. Horn, M.R.C.PATH.; M. G. Wells and C. E. Andrew, B.Sc. 225	E.C.T. and Cardiac Arrhythmia P. J. Ward, M.B. 229	Glucagon in Management of Perforated Oesophagus R. G. Pickard, F.R.C.S. 232
TSH Level and Thyroid Function W. M. G. Tunbridge, M.R.C.P., and others. 226	Malaria Transmission and Fetal Growth K. A. Harrison, F.R.C.O.G. 229	Periodic Fever T. H. Barrie, M.R.C.P. 232
Dangers of Oxytocin-induced Labour to Fetuses M. Thierry, M.D. 226	Schistosomiasis and Irrigation H. B. L. Russell, M.R.C.S., D.T.M.&H. 229	Non-union of the Scaphoid F. C. Dwyer, F.R.C.S. 232
Diet and Coronary Heart Disease J. Yudkin, M.D.; Surgeon-Captain T. L. Cleave, M.R.C.P. 226	Alpha-fetoprotein and Rh Alloimmunization A. Jouvenceaux, M.D., and others. 230	Management of Lithium Treatment E. H. Bennie, M.R.C.PSYCH. 232
Consistent Chromosome Abnormalities in Acute Leukaemia Judith H. Ford, PH.D., and others. 227	Renal Amyloidosis in Chronic Granulomatous Disease R. de Seigneux, M.D., and others. 230	Side Effects of Lithium Carbonate J. M. Himmelhoch, M.D., and I. Hanin, PH.D. 233
Antiemetics, Prolactin, and Breast Cancer P. K. Bondy, F.R.C.P., and T. J. Powles, M.R.C.P. 228	Haemodialysis and Forced Diuresis for Tricyclic Antidepressant Poisoning R. R. Bailey, F.R.A.C.P., and others. 230	Oedema of Mountains A. Pines, F.R.C.P.ED. 233
Larrey and Débridement D. H. Patey, F.R.C.S. 228	Poisoned Children J. R. Sibert, M.R.C.P. 231	Screening for Hypertension T. W. Preston, M.D. 233
	Liver Hamartomas in Patients on Oral Contraceptives M. Elstein, M.D., M.R.C.O.G. 231	Economics in the N.H.S. A. R. Manners, M.B., D.M.R.D. 233
		N.H.S. Contraceptive Services M. J. Emslie, M.R.C.G.P.; J. P. Lewin, M.B. 233

Clean Air Operating Room Enclosures

SIR,—There is always a tendency to modify surgical inventions by surgeons and manufacturers and sometimes this results in loss of efficiency. The first alarm that my design of body exhaust system might not be functioning as it should was from reports that surgeons in different parts of the country were exhausted and drenched with sweat from intolerable conditions inside the clothing. My chagrin later was eased by hearing that the cause was obsolescent air conditioning in the main operating room, but imagine now my alarm when operating for the first time in my own hospital in the latest model of clean air enclosure, which has just been installed, to find the body exhaust clothing intolerable because of inadequate air extraction. The negative pressure inside the gowns in this new installation was hardly detectable compared with the three installations already in existence in which all our research in bacteriological matters has been based. The manufacturers had "set" the body exhaust rate and deliberately taken away the adjusting key so that we could not "fiddle" with it. When eventually the exhaust rate was raised to the level I have always been used to the system was satisfactory.

What I find alarming is the possibility that surgeons who do not understand the system may put pressure on the manufacturers and purely in the interests of their personal comfort may destroy the efficiency of the installation from the bacteriological point of view. In my view, the body exhaust system must function with a considerable margin over resting conditions so that deep expirations of a surgeon doing hard

physical work, combined with a bellows effect of the gown in certain movements of the arms, should not convert a negative internal pressure into a transient positive pressure with expulsion of contaminated air into the enclosure. For reasons of economy no attempt has been made in my design to achieve hermetic sealing round the windows of the mask, and the clothing functions by the "fail safe" effect of negative internal pressure making all leaks in the direction of environment to inside of gown. The Howorth operating enclosure uses a conventional operating room light so that there is air turbulence under the light and therefore close to the open wound. This situation is permissible only if the air in the enclosure is absolutely protected from contamination by emissions from the surgical team by a body exhaust system which is functioning with a margin above minimal requirements.

It is to be accepted that the rate of air extraction which absolutely will guarantee efficiency may produce a noise level inside the head piece which may be disconcerting for those who test it for no more than a few minutes. Inside the head piece this noise restricts communication to shouting and mimed signals, if a telephonic system is not used, but even so it is astonishing how this environment is forgotten once the surgeon becomes absorbed in the surgical procedure. In this unit I estimate that some 9,000 man hours are spent per year in these conditions, and we have no complaints from new residents or nursing staff and we do not use telephonic communication. New residents become completely accustomed to

the unusual conditions within the time of the first operation.

In my view, the correct rate of extraction from the gown should be such that it reduces the internal pressure in comparison with the environment by $\frac{1}{4}$ – $\frac{1}{2}$ in (6.4–12.7 mm) water gauge. This test is quite easily done (in non-sterile rehearsal) by passing a tube from a water gauge through the cuff and up the sleeve so that it reaches the interior of the head piece. Tests by expiration and bellows action of the gown should not cause a positive pressure. The danger in reducing the volume of air exhausted from the gown obviously will be increased if the gown leaks, so requests for a gown to be made to open down the back after the manner of conventional operating gowns (instead of being put on over the head as in the present design) are particularly dangerous. Even worse is the request that the head part of the gown should be made as a separate cowl in order that the surgeon may more easily turn his head from side to side. It is an essential feature of the present design that the head piece and the body of the gown share one continuous internal space, with no constriction round the neck to obstruct warm air rising from the body into the head piece where it is extracted. If a separate head cowl is used the internal volume will be small and the sudden expulsion of air from the lungs will seriously effect the internal negative pressure, and there will be no protection as a result of the large reservoir-effect of direct communication with the main volume of the inside of the gown.

As it has been developed and used for eight years at Wrightington the body exhaust system is a simple and economic

method of maintaining air cleanliness at a level of two to three colony-producing particles/100 ft³ (2.8 m³) air in the presence of four persons working as an active operating team in a relatively small enclosure. To equal this without complicating the installation it is necessary for surgeons to suffer what may at first seem certain inconveniences, but if they appreciate the rationale behind the design they will very soon become adapted to it.—I am, etc.,

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Deaths during Dentistry

SIR,—It is inconceivable that in this day and age one can read in the *B.M.J.* that three deaths have occurred in England recently during anaesthesia administered by dentists while at the same time carrying out dental treatment. That this should happen in Britain, where there are more trained anaesthetists than anywhere else and where this has been the case for over 100 years, is incomprehensible. In Sweden, where modern anaesthesia started only in the forties, all dental anaesthetics are administered by trained anaesthetists assisted by qualified nurse anaesthetists.

In the past when dental anaesthesia consisted of nitrous oxide and air or oxygen given by the dentists before starting treatment it was a relatively safe procedure. Since the advent of intravenous anaesthesia, however, it can be a dangerous procedure and should be the sole responsibility of someone who is proficient in intubation and in resuscitation and competent to deal with inhalation of foreign bodies or sudden laryngospasm.—I am, etc.,

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Respiratory Recording from the Oesophagus

SIR,—In a recent Scottish medical negligence case in which I was concerned (10 February 1973, p. 365), in which liability was established against the hospital board and the anaesthetist, the pursuer's (that is, the plaintiff's) case was that the cardiac arrest that occurred was an anoxic one resulting from placement of the endotracheal tube in the oesophagus instead of in the trachea. The pursuer was the curator of the patient, who at the time of the operation was a fit and healthy woman in her mid-twenties but whose mental capacity had been seriously and permanently impaired as a result of the anoxia which she suffered.

One of the factors put forward by the defence in support of their case was that the reservoir bag in the Magill circuit had been seen to move rhythmically as if in spontaneous respiration; accordingly they maintained that this could not have happened if the endotracheal tube had been in the oesophagus. In cross-examination on this point evidence was given for the pursuer to the effect that rhythmical movement of the bag could nevertheless occur even if the tube was in the oesophagus. Textbooks and clinical experience were referred to in support of this proposition. The credibility of this evidence was nevertheless strongly

challenged by the defence in a situation in which procedural rules of evidence made it impossible for the pursuer to refute the challenge by adducing further corroborative evidence. The decision in the case, which was subsequently affirmed on appeal, did not turn upon the point, but since the existence of this little-known but significant physiological phenomenon has now been confirmed in this department by investigations in three patients, I feel that the evidence resulting from a detailed experimental recording should be made available.

During strong inspiratory effort with the glottis closed intrapleural pressures of 54 cm H₂O have been recorded,¹ and as oesophageal pressure may be related to intrapleural pressure² it is likely that gas would flow into an intubated oesophagus during obstructed respiration. During spontaneous respiration in three anaesthetized, intubated adults, when the oesophagus was also intubated and the endotracheal tube obstructed "tidal volumes" values of up to 180 ml were recorded at the oesophageal tube. The following case is illustrative of this phenomenon.

A 65-year-old woman who four weeks previously had had a hiatus hernia repaired was given nitrous oxide, oxygen, and halothane anaesthesia via an endotracheal tube with spontaneous respiration for removal of a breast. She had volunteered for the investigation to be made during the course of this operation, having had the proposed experimental procedure explained in detail. This was considered to cause no risk to the patient as respiratory obstruction would be produced for only 15-20 seconds and such periods of apnoea are easily exceeded by most people. The oesophagus was intubated with an 8-mm nasal tube to which was attached an electromanometer and a Fleisch pneumotachograph head, which was calibrated with three known air flows. The endotracheal tube was also connected to an

electromanometer. Both pressure traces, the flow trace, and its integral with time and volume were recorded on a Devices pen recorder. The endotracheal tube was obstructed for 20 seconds and the recording seen in the figure obtained. It can be seen that this far from fit elderly woman was able to generate flows of air into her oesophagus of over 50 litres per minute and a "tidal volume" of over 50 ml rhythmically in and out of her oesophagus.

The actual movement of the reservoir bag will depend upon the fresh gas flow into the Magill circuit, but provided this is below 8 l./min it seems that fit young adults may be able to move the reservoir bag of the circuit and mimic normal respiration if the oesophagus has been inadvertently intubated and the airway obstructed by the insertion of a throat pack.—I am, etc.,

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¹ Wyle, W. D., and Churchill-Davidson, H. C., *A Practice of Anaesthesia*, p. 72. London, Lloyd-Luke, 1972.

² Mead, J., and Milic-Emili, J., in *Handbook of Physiology*, Section 3, ed. W. O. Fenn and H. Rahn, Vol. 1, p. 363. Washington, American Physiological Society, 1964.

Comparison between Free Thyroxine Index and Effective Thyroxine Ratio

SIR,—Dr. E. G. M. D'Haene and his colleagues (21 September, p. 708) quote our article of 1965¹ in which we described the derivation of a free thyroxine index from the protein-bound iodine (P.B.I.) and resin uptake of ¹²⁵I-labelled T-3 from serum. The latter value was expressed as a ratio between the uptake from serum and that from a control pooled serum (T-3 resin uptake ratio). The use of this index corrected for changes in binding protein (such as occur in pregnancy) and also more clearly separated abnormal from normal states of thyroid function than did either the P.B.I. or T-3 resin uptake ratio alone.

The index, as introduced, was calculated from the product of P.B.I. and T-3 resin uptake ratio values and not, as stated by Dr. D'Haene and his colleagues, by dividing the value for the P.B.I. by the respective T-3 resin uptake. More recently² a free thyroxine index was calculated from results of P.B.I. and Thyopac-3 values and, in this instance, the index is derived by dividing the P.B.I. value by that for Thyopac-3. It is here that confusion may arise and this may be avoided if careful attention is paid to the procedures employed for measuring, and also reporting, the T-3 resin uptake test.

In the Thyopac-3 method the quantity of radioactive T-3 left in the serum phase is measured and compared with a control serum and thus reflects directly the ability of serum proteins to bind thyroid hormone. In contrast, in our original T-3 resin uptake method the amount of radioactive T-3 taken up by the resin from serum is determined and related to that of a control pooled normal serum—that is, there is an inverse relationship to the number of unsaturated sites on thyroxine-binding proteins and thus to the Thyopac-3 values.³ The T-3 B.C. index obtained with the ResOmat kit, though described as a resin uptake test, is in fact similar to Thyopac-3 in that the