Rational housing for surgical patients

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The surgical patient is the Achilles heel of any hospital system concerned with the prevention of cross-infection. In no other large group of patients is the provision of a bacteriologically safe environment so necessary and so amenable to rationalization. Yet in Britain and elsewhere, for more than half a century the interplay of sociological and technological factors has combined to confuse a rational solution to the problem of how best to provided safe housing for surgical patients. Not surprisingly confusion postpones the sustained executive action required for an improvement in the hospital environment of patients. At the hub of the problem lies the argument on the sources of infection of surgical wounds. As in all such controversy the proponents make firm statements which are all too often accepted by the laity as articles of faith. What for example is today's hospital architect, engineer, or planner to make of the following recent pronouncements, 'The groundwork for Post-operative infection is laid in the operating theatre . . . the ward does not play a significant role in the development to wound infection' (Cruse, 1977) or 'the vast majority of surgical wound infections derive from micro-organisms of endogenous or extrinsic origin introduced into the wound during operation' (Dunn, 1979). It would not be surprising if such comment induced those planning new hospitals to believe that surgical ward design is of little import in the control of wound infection. However, should they read more widely they will find completely contradictory evidence as to the source of the cross-infection hazard in surgery. In one original and comprehensively controlled study of post-operative wound sepsis in general surgery (Thomson, Larsen & Jepson, 1970) the authors conclude, 'The air in the ward is of major importance concerning the route of infection in post-operative wound infections caused by *Staphylococcus aureus*. . . . Post-operative wound infections by *S. aureus* originate mainly in the wards . . . the main concordance is found between ward air and wound infection which indicates the ward air as the source of staphylococcal infections.' Such observations were supported earlier by those of the Ad Hoc Committee on Trauma of the National Research Council (Committee on Trauma, 1964). After comprehensive study of the relationship between the bacterial flora found in the operating theatre and patient during operation, and the infecting bacteria in post-operative wound infection, the committee concluded that there was no correlation.

Controversy

In recent years, many well controlled studies have emphasized the importance of both the pre- and post-operative environment as opposed to that of the operating theatre as the major source of cross-infection of surgical wounds. (Jepson *et al.*, 1970; Thomson *et al.*, 1970; Smylie *et al.*, 1971; Davidson *et al.*, 1971; Irvine, Johnson & Amstutz, 1974; McLauchlan *et al.*, 1976; Bröte & Nilehon, 1976; Bengtsson, Hambraeus & Laurell, 1979). It might be thought, therefore, that planning authorities everywhere would by this time have reached a consensus enabling them to evolve a standard ward design capable of controlling cross-infection among surgical patients. That they have failed to do so is largely the fault of the expert bacteriological advice which they seek, and which they find unnecessarily complex. Controlled studies showing a large reduction in cross-infection related to improved ward design tend to be dismissed as either statistically unproven or ecological coincidence. As far as the operating room is concerned Charnley & Eftekhar (1969) found that the supply of ultra-clean air was mainly responsible for much reduced infection rates following total hip replacement operations. The results of a carefully designed and costly multi-centre trial, considered necessary to test this claim have yet to appear but it seems possible that it will not be substantiated. Against this background there is now a real need for a Consensus Development Programme in the UK along the lines of that recently initiated by the National Institute of Health in the United States of America (Lowe, 1980) which could provide a more organized system of assessing new methods and procedures and identify what is well validated and worthy of wide acceptance. An important element in such a programme is the inclusion of the public as the consumer, alongside scientists, practitioners and other in a conference aimed at reaching general agreement as to whether an advance in technology represents increased efficacy, safety and amenity for both the patient and the procedure.

AN ORGANIZED APPROACH TO RATIONALIZATION

If such a conference were to adjudicate today on the subject 'Rational Housing for Surgical Patients' what evidence could be presented 100 years after Ogston's discovery which might lead to the consensus so urgently required for safer surgery? Firstly and most significantly, despite hopeful statements to the contrary (Ayliffe, Lilley & Lowbury, 1979) *S. aureus* shows signs of not only retaining, but renewing its potential as the principle cause of serious and often life threatening post-operative sepsis (Staphylococcus News Sheet, 1980). How Ogston's patients had to cope with this threat is demonstrated in fig. 1 (Aberdeen Royal Infirmary, 1st floor plan, as given in Bristow & Holmes Report of 1866). 88 beds are distributed between 9 large naturally ventilated rooms, to all intents and purposes just one large ward with only 2 water closets and 2 bathrooms. Were his patients so badly off when compared with the Nightingale type ward provided for the Professorial general surgical unit in the 'new' Aberdeen Royal Infirmary which replaced nineteenth-century building and opened in 1937?

In the 1950s, as many as 90 patients distributed between male and female ends of the professorial ward, each of which is provided with only 2 water closets and 1 bathroom, and the overall post-operative wound sepsis rate during that period was always around 30 per cent with a measurable cross-infection rate (*S. aureus*) varying between 11 and 15 per cent. By the mid 1960s, bed complement had been reduced to approximately 66 patients but the overall post-operative infection rate measured over a 2-year period was 32.3 per cent with a staphylococcal cross-infection rate 11.5 per cent (Smylie *et al.,* 1971). Approximately 60 per cent of the surgery performed in this unit could be classed as clean. During that period, seven deaths were associated with staphylococcal wound sepsis and septicaemia, mainly as a result of infection with the then epidemic strain Type 84/85–. During 1966, this professorial surgical unit transferred to new race-track type of ward accomodation specifically designed to combat cross-infection (Smylie *et al.,* 1971) and the old ward was then re-occupied by orthopaedic surgery. Inevitably the new incumbents inherited the cross-infection problems peculiar to this Nightingale type of ward construction. During 1972, several years after the epidemic strain 84/85– had disappeared both from patients and staff in the new professorial ward unit, it was still being isolated as a cause of sepsis among orthopaedic patients in the old ward. During October 1976, the female end of the ward was closed following 8 cases of serious staphylococcal infection of the same antibiotic insensitivity pattern over a 6-week period, accompanied by an outbreak of staphylococcal skin

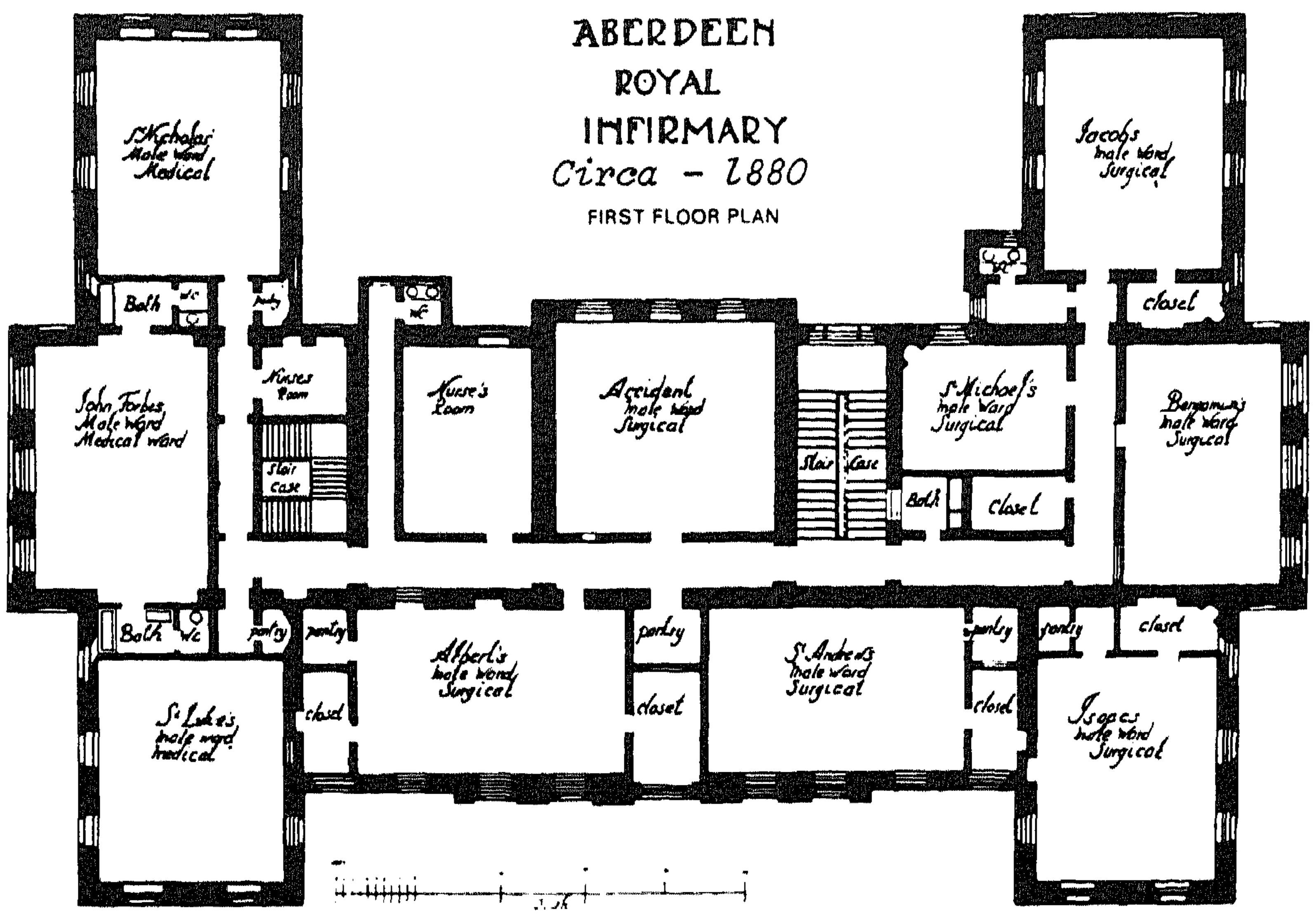

Fig. 1 Surgical ward in the 1800s: Old Aberdeen Royal Infirmary built 1840.

infection in nursing staff. By this time a 24 per cent post-operative wound infection rate of primary prosthetic replacements was being recorded within the unit. The female ward was re-opened during November, 1976, but despite a reduction in bed complement to only 56 patients, another emergency closure, this time of the male end, was forced upon the unit following a gradual build up of staphylococcal sepsis during 1977—January, 2 cases, February, 3 cases, March, 10 cases, April, 8 cases, May, 4 cases, June, 12 cases by which time a cross-infection rate with multiple antibiotic-resistance staphylococci approaching 30 per cent was being recorded amongst male orthopaedic patients (Smith *et al.,* 1980). New epidemic staphylococcal phage types were identified notably Type 94/96, and 42E. In this orthopaedic unit approximately 90 per cent of operations performed could be classified as clean. The history of air hygiene in this ward over the years is revealing. During 1957, before a change from woollen to cotton blankets, and during the busiest period of the day (7.30 a.m.–11.30 a.m.) a mean average count of 146 bacteria-carrying particles per cu ft of ward air including 2.54 coagulase positive staphylococcal particles was recorded (Smylie, 1960). Following the introduction of cotton blankets and terylene bed-curtains and the reduction of the bed complement, such differential counts have been repeatedly and respectively demonstrated as lying between 40 and 70 and 1.6 and 1.9 per cu. ft (Smith *et al.,* 1980).

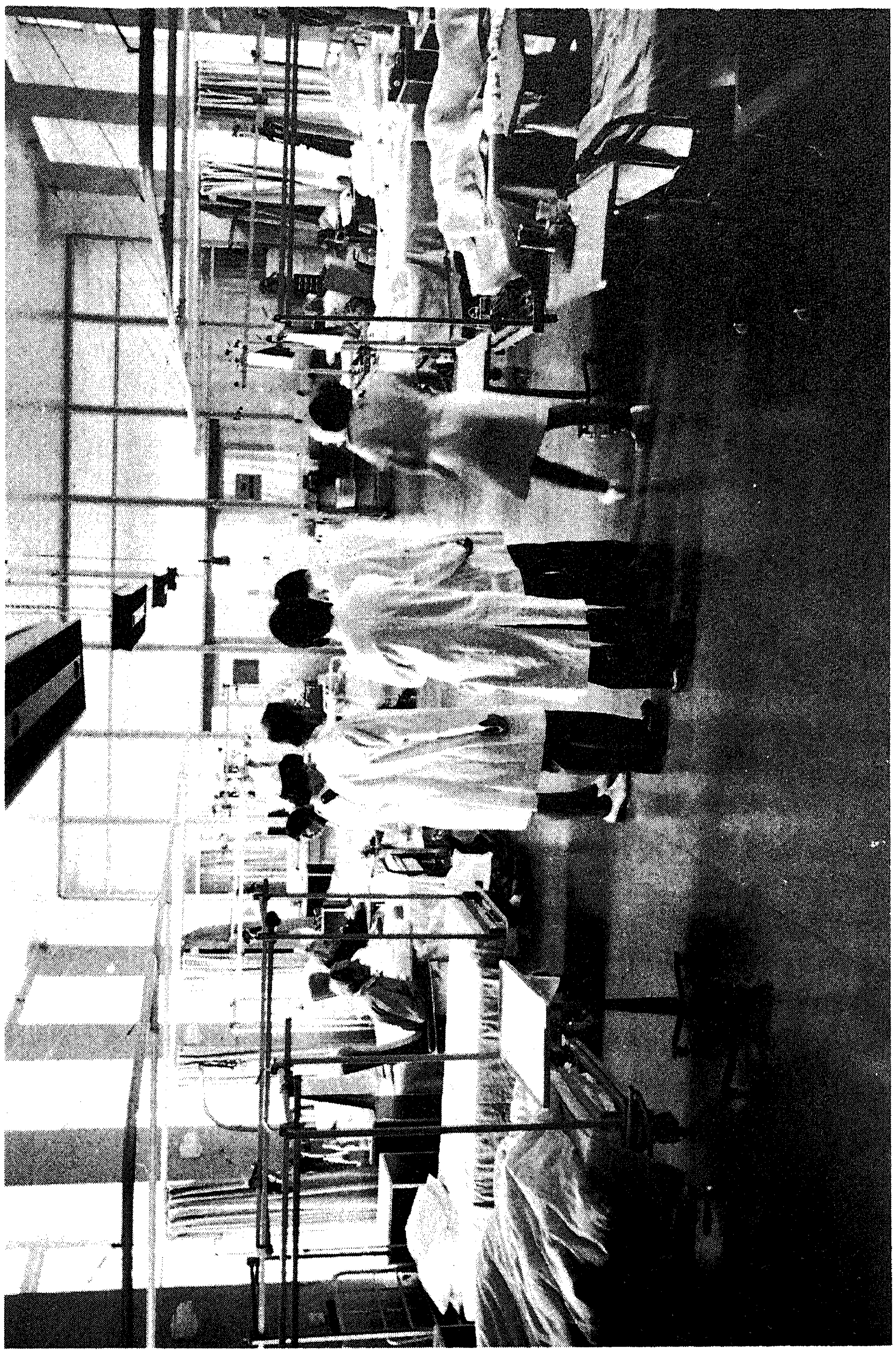

Fig. 2 Housing for surgical patients in the 1980s orthopaedic ward Aberdeen Royal Infirmary.

Part of the work performed by the Aberdeen Orthopaedic surgical unit is carried out at Stracathro Hospital, some 40 miles south of the city, and built as an Emergency Medical Services hospital at the outbreak of the Second World War. Air hygiene studies carried out approximately weekly for the past two years show ward air to contain an average of 40 B.C.P.'s per cu ft of ward air when all beds are occupied, with a yield of 0.95 particles of *S. aureus*. Settle plates exposed while the slit sampler was in use have shown occasional settle rates as high as 180 colonies per hour with as many as 3 to 5 colonies of *S. aureus* per plate. This ward houses the total hip replacements carried out in an ongoing trial of the Trexler Surgical Isolator (McLauchlan *et al.,* 1976) the results of which to date show no statistically significant differerence in the rate of post-operative wound infections of hips replaced in either a conventional plenum-ventilated operating room or within the sterile air environment of the Trexler Isolator. All staphylococcal hip infections so far identified in this trial relate to strains isolated from the ward environment and not the environment of the operative procedure. The remaining hip infections yielded mixed growths of *E. coli, Strep. faecalis, Pseudomonas* or diphteroids, usually between the 7th and 10th post-operative day, and were aetiologically related to heavy immediate wound soakage and faulty drainage. The application of the Trexler Isolator to clean surgery may yet prove to be the best experimental model available for investigation of the sources of surgical wound infection.

Building for the Future

In contrast to all this, the history of the professorial surgical unit since its move to new accommodation during 1966 is revealing. fig. 3 shows the interior of the single-bed patient accommodation of the ward. fig. 4 records the bacteriological events of the first two years of occupation in contrast to those of the last two years of work by the same unit in the old Nightingale ward. At the end of the four year study period, despite a demonstrable 72 per cent reduction of staphylococcal cross-infection following transfer, there was a tendency to devalue the significance of the result as being in some measure due to the decline of the staphylococcus as a hospital pathogen. That this was not necessarily the case has been shown by the subsequent events reported over the past 14 years from the Orthopaedic Unit now occupying the old Nightingale ward. Moreover, the reported and sustained continuance of the low cross-infection sepsis rate in the new ward shows no evidence that the new design is becoming less safe (Smith *et al.,* 1974; Smith *et al.,* 1980). It is the author's belief that the table which compares the standard of air hygiene in the Nightingale ward with that

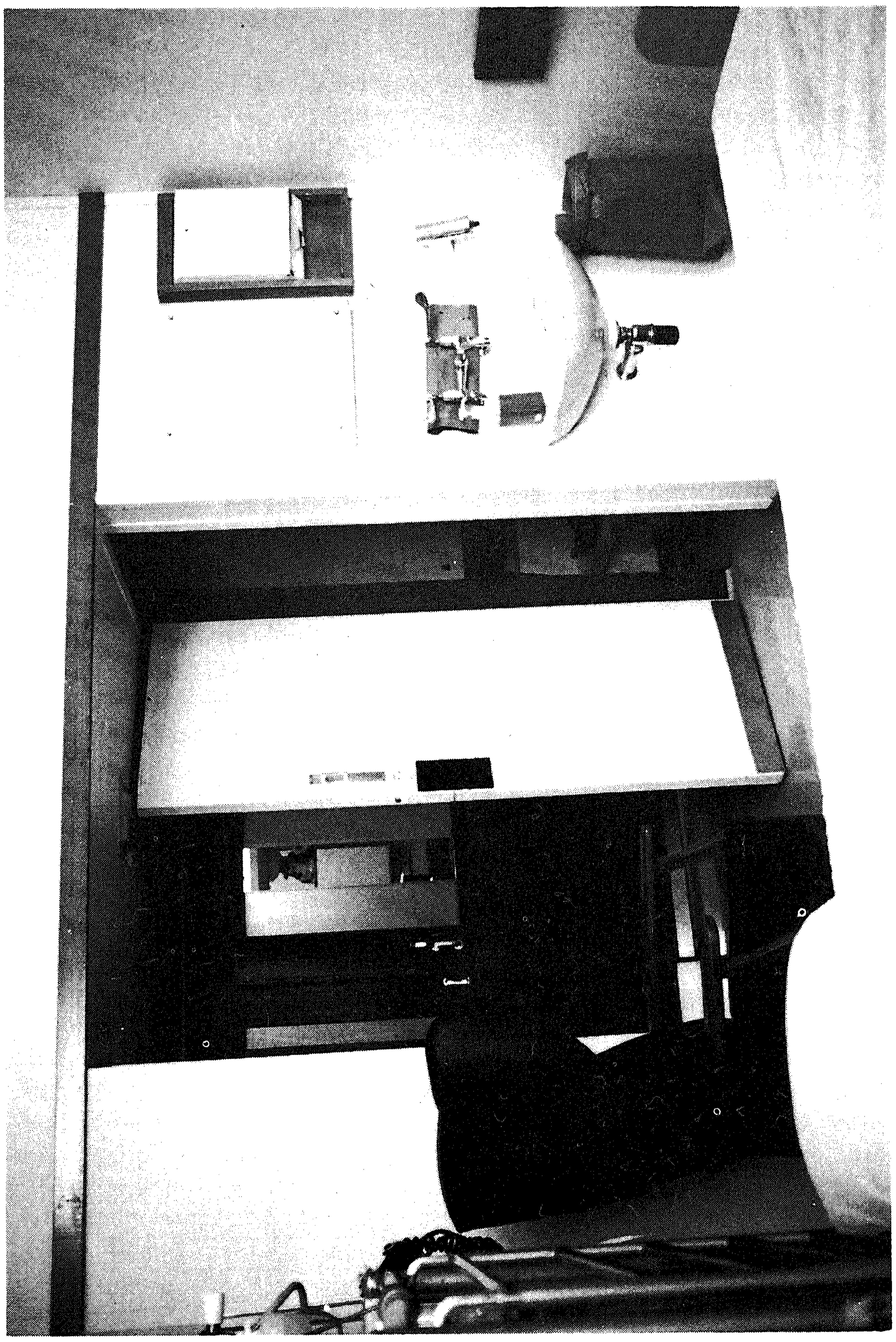

Fig. 3 Single-bed accommodation in new surgical ward Aberdeen Royal Infirmary.

produced by the new ward design, identifies the major safety factor required for the safer housing of surgical patients. Other workers have demonstrated both the increased bacteriological safety of single-bed room isolation, (Williams *et al.*, 1962; Jamieson *et al.*, 1971, Ayliffe *et al.*, 1971) and the significant absence of any evidence that ultra-clean operating environments reduce the incidence of post-operative wound infections (Shaw, Doig & Douglas, 1974).

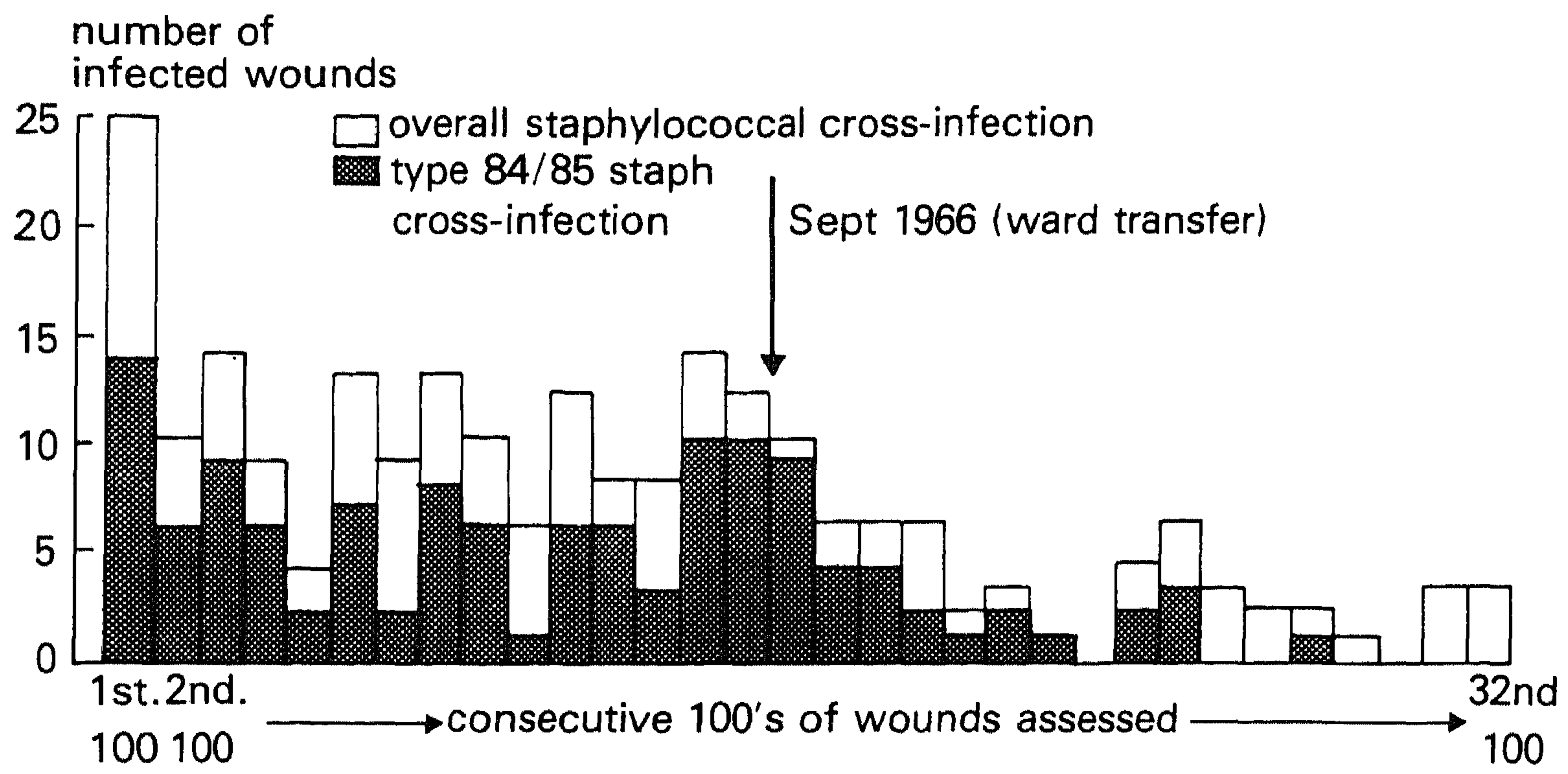

Fig. 4 Staphylococcal infection in old and new surgical wards of Aberdeen Royal Infirmary.

Table 1.

Comparison of numbers of bacteria-carrying particles per cubic foot of air in surgical wards of differing design

	OLD WARD (33 or 27 beds—all in one room) (No proper ventilation) COUNTS			NEW WARD (58 beds—24 single-bed rooms) (— 6 four-bed rooms) (— 2 five-bed rooms) (All under controlled ventilation) COUNTS		
		Total	*S. aureus*		*Total*	*S. aureus*
1957	7.30 a.m.	214	3.2		–	–
	10.30 a.m.	78	1.9		–	–
1958	7.30 a.m.	75	1.8		–	–
	10.30 a.m.	62	1.6		–	–
1965-67	10.30 a.m.	84	1.6		–	–
1968-70	10.30 a.m.	72	1.8	Single	5	0.04
				4-5 beds	7	0.09

CONCLUSIONS

All this must surely now encourage a consensus on a rational approach to safe housing for surgical patients. Such rationalization would perforce take account of the following observations:

1. For the foreseeable future pyogenic staphylococcal infection will continue to be a serious hazard to post-operative wounds in multi-bedded ward environments lacking controlled ventilation.
2. Nightingale ward design is a failure in terms of safe and therefore rational housing for surgical patients.
3. In any acute surgical receiving ward, counting patients at risk from infection post-operatively, or already infected, or requiring intensive care, it will be found that approximately 50 per cent of patients are worthy of the protective isolation of a single-bed room under controlled ventilation.
4. Post-operative patients at risk from infection and placed in single-bed room isolation under controlled ventilation benefit from reduced sepsis rates as compared with those in Nightingale wards.
5. Trials of ultra-clean operating room conditions when throughly monitored bacteriologically do not appear to contribute to any significant reduction in post-operative wound sepsis rates.
6. Broadcasts of pyogenic staphylococci in large multi-bedded Nightingale type wards are uncontrollable and an infection hazard to all patients in that ward. Conversely broadcasts from a shedder or infected patient in a single-bed room efficiently ventilated is controllable and do not appear to constitute an airborne hazard to adjacent patients in similar accommodation.
7. As few as 5 air changes per hour of fresh moderately filtered air delivered to single-bed rooms at ceiling level through a simple in-put diffuser grille will control the air-borne infection hazard. The addition of forced intra-room extraction is not only unnecessary but decreases the desired dilution effect.
8. The absence of the dilution of controlled ventilation leads to massive increments of infectious particles on all exposed surfaces of large multi-bedded wards, and higher acquisition rates of both nasal and skin carriage of *S. aureus* in the patients of such wards.
9. Mounting public pressure for a much improved standard of housing within the wards of today's hospitals would most certainly be presented as equally important to the participants of a Consensus Conference adjudicating on this issue. Perhaps the most revealing and at the same time most depressing comment likely to be made concerning too many of

today's surgical wards, is that they represent a standard of housing far below that which most patients leave behind when they are forced to enter hospital.

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