Contemporary Issue

Designing Hospital for better Infection Control : an Experience

Lt Col SKM Rao

Abstract

The physical design of hospital is an essential component of a hospital's infection control strategy, incorporating infection control issues to minimise the risk of infection transmission. Hospital design therefore, needs to consider the separation of dirty and clean areas, adequate ventilation, lighting and storage facilities and design of patient accommodation areas, including adequate number of wash hand basins and single bed facilities. A 250 bed general hospital was planned keeping in view structural and design elements necessary for success of a good infection control programme. Various National and International Standards like BSI recommendations, JCAHO, IC Standards, DHSS, ASHRAE, AIA and OSHA were studied and compared with our planning parameters. Planning of ward unit, ICU, Operation theatre and Isolation wards were especially reviewed in the light of recent knowledge available in the field of hospital acquired infection and modifications were carried out. Need for effective identification of potential infections, risks in the design of a hospital were stressed. Engineering controls required to reduce the concentration of infectious droplet nuclei in the air and prevention of transmission of disease were highlighted.

MJAFI 2004; 60 : 63-66

Key Words : Design; Hospital infection; Intensive Care Unit; Operation Theatre; Prevention; Ward

Introduction

The physical design of hospital is an essential component of a hospital's infection control strategy, incorporating infection control issues to minimise the risk of infection transmission [1]. The role of infection control in the design of facilities has become increasingly visible as communicable diseases like tuberculosis and multidrug resistant organisms have caught the attention of the media affecting both consumer awareness and regulatory agencies responsible for environmental health and sanitation [2].

It is the imbalance between classical triad of epidemiology i.e. agent, host and environment which leads to the initiation of disease process and to which hospital acquired infections are no exception. The hospital environment plays an important part in the development of infection. Whereas, the hospital may not have such control over the host factors and agents, the hospital certainly is responsible for the environment that surrounds the patients. By controlling and adequate sanitising of the environment of the host, the hospital authorities can markedly reduce the incidence of hospital acquired infections [3].

Most of the hospitals in developing countries are not scientifically designed, physical facilities are most inadequate and wards are overcrowded. There are hardly any separate arrangements for septic and clean cases, especially in surgical and maternity wards. Patient placement is generally found to be faulty. Requirements of air conditioning and ventilation are not met properly, thus increasing the risk of infection transmission. Overcrowding in nurseries and ward units promotes risk of cross infection. It is of paramount importance to consider hospital infection control measures while planning various departments like wards, operation theatre (OT), intensive care unit (ICU), central sterile supply department (CSSD), dietary, laundry etc. However, presently only ward, ICU and OT are being discussed here.

Planning parameters

The aim of a hospital planner is to achieve a good hospital architectural design for better infection control. A 250 bed general hospital has been planned keeping in view structural design elements necessary for success of a good infection control policy. At the planning stage itself certain criteria and principles were kept in mind to be fulfilled [4,5].

a) The design should support functional segregation of OPD, inpatients, diagnostic services and supportive services so that mixing of patient flow is avoided.

b) Separation of critical areas like OT, ICU from general traffic and avoidance of air movement from areas like laboratories and infectious diseases wards towards critical areas.

c) The design should support concept of zoning and ventilation standards in acute care areas.

d) The clean corridor and dirty corridor should not be

Associate Professor, Department of Hospital Administration, Armed Forces Medical College, Pune - 411 040.

adjacent and they should facilitate traffic flow of clean and dirty items separately.

e) Isolation wards for infectious cases to be kept out of routine circulation.

f) Adequate number of wash hand basins should be provided within the patient care areas and nursing stations with a view to facilitate hand washing practice.

g) Separate arrangements for garbage and infectious waste removal from wards and departments in the form of separate staircases and lifts.

h) Construction of isolation rooms within the wards including ICU and acute care areas.

i) Provision of airlock and anteroom before entering into critical care areas.

Design of Ward Units

Control of infection in wards not only requires application of the principles of asepsis and hygiene but also considerations of design, equipment and ventilation of wards. Hand washing has been recommended as the single most important practice to control hospital acquired infection. The number of sinks and their placement should be thoughtfully planned to encourage health care worker to practise hand washing before and after every patient care activity. Ayliff et al infer that though nursing of each patient separately is ideal, at least 2-4 single rooms for a 30 bed unit are sufficient. Moreover, overcrowding in pavilion wards should be avoided by keeping centres of beds at least 8 feet apart.

A general ward was planned based on bed strength ranging from 24-32 beds on rigs pattern where 2 single bed rooms, 2 four bedded rooms and rest 6 bedded rooms were planned. One wash hand basin (WHB) each for these rooms averaging one WHB per six beds was provisioned. Floor space area per bed was kept to 7 sqm excluding central corridor of 2.4 meters. Single bed rooms were given 14 sqm and distance between centres of beds in 6 bedded rooms was coming to more than 2.5 meters [6].

Authorities have recommended that whenever possible, a patient known or suspected to harbour transmissible microorganisms should be placed in a single room with hand washing and toilet facilities. A single room helps prevent direct or indirect contact transmission or droplet transmission. A checklist for planning of isolation rooms in wards or as a separate ward is tabulated in Table 1 [4,7,8].

One to two standard isolation rooms per ward unit were planned throughout the hospital with WHB in room, shower, toilet and bathroom. Door with self closing device and a normal window AC were provisioned for these rooms.

Table 1

Isolation room checklist

	Class 'S'*	Class 'N'*	Class 'P'*
Hand wash basin in room	Yes	Yes	Yes
Ensuite bathroom (Shower, toilet, WHB)	Yes	Yes	Yes
Door with door closer	Yes	Yes	Yes
Airlock		Yes	Optional
Sealed room, door		Yes	Yes
Pan sanitiser (near room)	Optional	Optional	Optional
Independent exhaust		Yes	
HEPA filters on supply	-	-	Yes
Air changes/hour	-	6-12	6-12

S - Standard isolation : for patients who require contact or droplet isolation; N - Negative isolation : for patients who require air borne droplet nuclei isolation e.g. Tuberculosis; P - Positive isolation : for patients who are profoundly immunocompromised e.g. transplant and oncology patients

As per standard guidelines a space should be provided to keep urine, stool samples of patients, their disposal, washing and storage of contaminated / soiled linen, place to make disinfectant solution and placement of bedpans etc [4,7,8].

Dirty utility and soiled linen room of size 10.5 sqm per ward with facilities for bed pan sink, Macintosh sink and slop sink is planned. Water supply of hot and cold water was catered and in addition janitors closet of 3.5 sqm for keeping mops and detergents was provisioned in each ward [6].

Planning of ICU

A number of professional and scientific bodies in the UK and USA have published guidelines on the design and layout of ICUs. All emphasize the importance of adequate isolation facilities, at least one cubicle per eight beds, sufficient space around each bed- at least 20 sqm, WHB between every other bed, ventilation including positive and negative pressure ventilation for high risk patients and sufficient storage and utility space. Floors and walls should be easily cleanable and non porous. Dirty utility should have separate stand / shelf per bed, bedpans, urinals, to be kept dry and hand wash solutions / basins at each bedside.

American Institute of Architects (AIA) guidelines for new constructions recommends the minimum number of hand washing facilities for patients, as one in the toilet room plus having a sink in patients room, will support infection control practices. Small cup sinks that challenge proper hand washing should be avoided. Improper placement of sinks can add to the environmental reservoir of contaminants. Sinks need to be convenient and accessible but nearby surfaces

should also be nonporous to resist fungal growth. Space beneath the WHB should not be used as storage place for fear of leaks and proximity to sanitary sewer connections [8].

ICU of eight beds with 2 additional isolation cubicles is planned. Each bed will have 14 sqm floor space and with adequate place for bed head unit and separate sterile supplies. Each isolation cubicle is planned with self closing door and airlock. Air lock is supposed to have following functions [6] :

a) They provide a barrier against loss of pressurisation and against entry / exit of contaminated air into / out of the isolation room.

b) They provide a controlled environment in which protective garments can be donned without contamination before entry into the room.

c) They also provide a physical and psychological barrier to control behaviour of staff in adopting infection control practices.

ICU is planned with 15 air changes per hour (5 fresh + 10 re-circulation) as per minimum ASHRAE standards. Positive pressure gradient of 15 Pa is recommended between isolation cubicle and main ICU. International recommendations for room pressures are as per Table 2 [4]. One WHB between two beds alongwith stands for holding hand wash solutions for each bed is planned to promote hand washing practice. A dirty utility with place to prepare fresh KLICK's solution (Sodium hypochlorite) and stand for bedpans, urinals along with bedpan sink, Macintosh sink and slop sink have been designed.

Table 2

Recommended isolation room pressures

Type of isolation	Room	Ensuite	Airlock
Class 'N'	-30 Pa	-15 Pa	-15 Pa
Class 'P'	+30 Pa	+15 Pa	+15 Pa

Automatic air curtain has been planned at the air lock and entry into patient care area in ICU, acute care wards, OT sterile area, neonatal ICU, delivery suites. They have the capability of keeping outside environment separate from inside environment in critical care areas.

Planning of Operation Theatre

There is a general agreement that the factors affecting occurrence of infection in operation theatres are siting and design of OT, ventilation, temperature, staff discipline, use of protective clothing and cleaning programme.

British Medical Council has recommended the following basic requirements for control of infections in OT :

a) Separation from general traffic and air movement of hospital.

b) Zoning i.e. sequence of increasingly clean zones from the entrance to the operating area with the aim of reaching absolute asepsis at operating site.

c) Easy movement of staff from one clean area to another without passing through dirty areas.

d) Removal of dirty materials from the suite without passing through clean areas.

Objectives of ventilation system in OT are recommended to be as follows :-

a) To dilute the bacteria generated by the operating team and patients in the theatre by appropriate air volume changes.

b) To prevent less clean air from neighbouring rooms entering the OT by using different air pressures.

c) To create an air flow pattern that carries contaminated air away from the operating table.

d) To provide a comfortable environment for the operating team and patients with controlled temperature, humidity and ventilation.

The following is planned for operation theatre complex of the hospital :

a) Sterile Zone

(i) Temperature: 23°C ± 3°C

(ii) Relative humidity : 40% to 60%

(iii) Fresh air allowance : 10 per hour with total air changes 25 per hour

(iv) Air filters : through HEPA filters with filtration level upto 0.3 microns and 99.97% efficiency with pre filters in the system.

(v) Positive pressure = 25 Pa

b) Other areas : Fresh air changes minimum 5 per hour and total 15 per hour. HDPE washable filters with filtration level upto 5 microns.

c) One separate dedicated AHU designed to maintain positive pressure gradient so as to ensure flow of air from sterile to clean and protective zone. Aluminium air conditioning ducts with differential pressure gauge / manometer across HEPA filters so as to detect clogging or reduced flow of air.

d) No shelves will be provided inside OT.

e) Purified water will be supplied for scrub with steel scrub and facility of dispensing of hand wash solution as well as water through foot control

f) Recommended floor surface is epoxy resin flooring, however, authorities in the channel were of the opinion that marble slabs of suitable size with copper

strips should be provided. Epoxy flooring has been found to be seamless, scratch proof, hard enough for wheeled trolleys, stain free and antistatic.

g) Laminar flow which is a low turbulence downward displacement air flow towards the operation zone through stainless steel perforated grills has been planned.

h) Air curtains at the entry of sterile zone have been planned.

i) Drains, sewerage pipes and water line have been avoided at least near and above OT sterile zones.

Conclusion

The role of infection control in the design of hospitals is increasing everyday with emergence of communicable diseases like tuberculosis, immuno compromised conditions like HIV/AIDS and multidrug resistant organisms. A 250 bedded general hospital has been planned keeping in view essential design elements necessary for success of a good infection control programme. Planning of ward unit, ICU, OT, isolation ward and cubicles were reviewed keeping in view standard guidelines available.

References

1. Aylifle GAJ, Lowbury E JL, Geddes AM, Williams JD. Control of hospital infection - a practical hand book. 4th ed, London I Chapman and Hall Medical, 1995;76-9.
2. Bartley JM. The role of infection control during construction in health care facilities. Am J Infect Control 2000;28(2):156-61.
3. Surveillance, Prevention and Control of Infection, Comprehensive Accreditation Manual Volume 5. Joint Commission of Accreditation for Hospital Organisations, USA Nov 2000;2-6.
4. Center for Disease Control and Prevention. Recommendations for the prevention of hospital acquired infection. Am J Infect Control 1996;22:267-92.
5. Caster CD, Barr BA. Infection control issue in construction and renovation : Infection control and hospital epidemiology 1977;18(8):587-96
6. Scales of accommodation for Armed Forces Hospitals 1982, Govt of India.
7. Health Care Facilities. In : American Society of Heating, Refrigerating and Air conditioning Engineers "ASHRAE" Hand book - HVAC applications. Atlanta : 1999;7.1-7.1.2.46-9.
8. American Institute of Architects, Academy of Architecture for Health. Guidelines for design and construction of hospital and healthcare facilities. 1996-97. American Institute of Architects, Press Washington 1996;102-5.

Maths, physics and chemistry professors are roaming in a park and they see a well.

Maths professor says I will measure its depth and he enters into the well but could not come out of it.

Physics professor says : I will measure its density and let you know that why the maths professor could not come out of the well.

Chemistry professor takes his diary and writes : Maths and physics soluble in water.