Review Article
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A Review of Design Features of Intensive Care Unit in General Terms

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Abstract

Intensive care units (ICU), self-contained places that have special equipment and personnel for following up life threatening diseases, injuries and potentially critical patients. It provides specialty and resource for supporting vital functions. Moreover, it provides opportunity to experienced practitioners and allied health personnel to use their skills. As in the world, different discipliner ICUs are identified and the use of them has become widespread in our country. Beside the ICUs that are incarcerated by department of Anesthesiology and Reanimation, there are ICUs belonging to departments of cardiology, cardiovascular/thoracic surgery, chest diseases, neonatology, neurology, neurosurgery, internal diseases, general surgery and emergency. Good design of ICUs provides comfort and security to patients or personnel and increase the success of treatment. Furthermore, it prevents the deficits that cannot be remedied later, and contribute renewing substructure of ICU in accordance to the current conditions. There is no single ideal geometry for the placement of ICU. The published recommendations suggest units or patient room groups from at least six beds for efficiency and economy, and up to eight to 12 beds for observation reasons.

Keywords: Design,Intensive Care Unıt

Intensive care units (ICU), self-contained places that have special equipment and personnel for following up life threatening diseases, injuries and potentially critical patients. It provides specialty and resource for supporting vital functions. Moreover, it provides opportunity to experienced practitioners and allied health personnel to use their skills[1].

The notion of modern ICU was created by Florence Nightingale in 1852-Crimean War for severely injured soldiers that needed special nursing service in one special area. Otherwise, the commencing of ICUs in United States came into existence with post-operative recovery rooms. In 1923, a unit which comprised of three beds was built for post-operative nursing of neurosurgery patients in The Johns Hopkins Hospital. Second World War, Korean War and Vietnam War led to important developments about cardiopulmonary resuscitation (CPR) and triage of ICU patients. In this period anesthesia and post-operative nursing developed. Furthermore, shock had been started to treat with blood products and intravenous fluids[2]. After a hundred years from Florence Nightingale, in 1952 the epidemia of polio laid the foundations of specialization on intensive care in Copenhagen. In this epidemia the respiratory muscle and/or bulbar paralysis caused respiratory insufficiency in 316 patients, then these patients hospitalized to a special area. In the Blegham Hospital, which is the infectious disease hospital in Copenhagen, the area that provided care to these patients is considered as an ICU in modern sense. The epidemia of polio proved the importance of ICUs and ventilators. In time the roles of these units have expanded and became a multidisciplinary area that all the high-risk patients were accepted. Especially in last 10-15 years the facilities of ICUs have showed rapid improvements. Beside developed facilities, the improvements in variety and number of the patients also led to requirements about physical properties and substructure of ICUs[3]. As in the world, different discipliner ICUs are identified and the use of them has become widespread in our country. Beside the ICUs that are incarcerated by department of Anesthesiology and Reanimation (picture 1), there are ICUs belonging to departments of cardiology, cardiovascular/thoracic surgery, chest diseases, neonatology, neurology, neurosurgery, internal diseases (picture 2), general surgery and emergency (picture 3).

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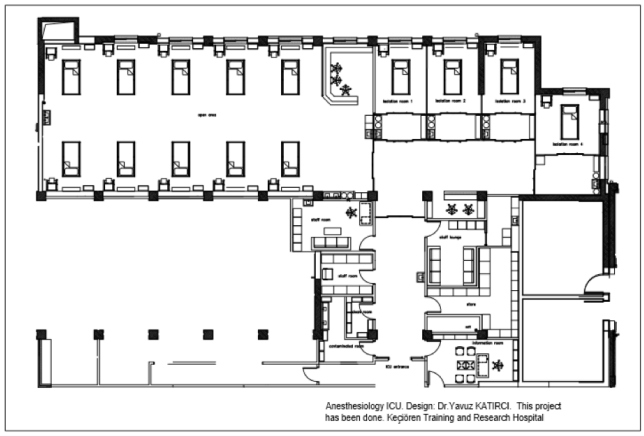
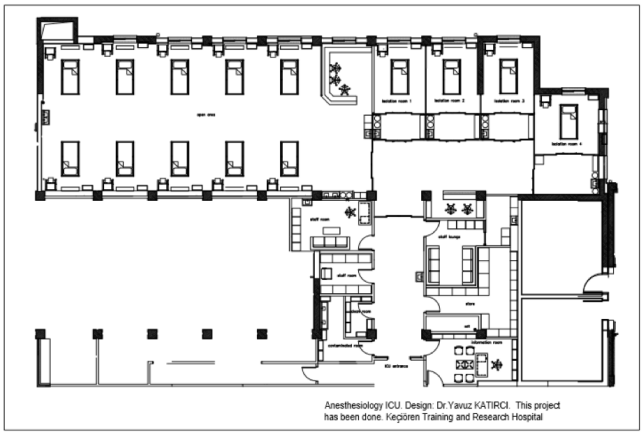
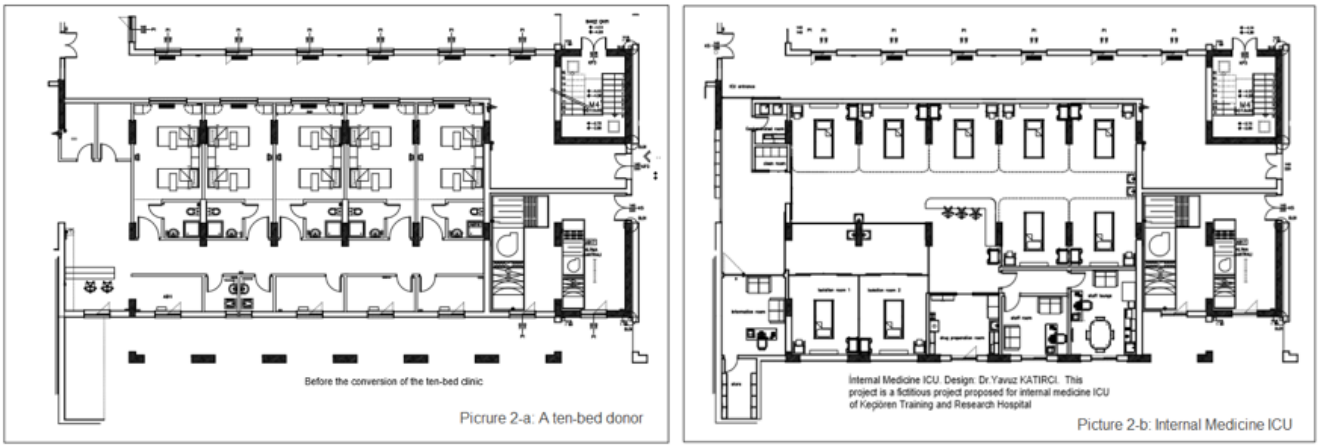


Picture 1. Third Level ICU.



Picture 2. Third Level ICU.



Picture 2. a A ten-bed donor clinic. b: Internal Medicine ıcu (Draft project Od donor clinic conversion to ICU)

GENERAL TERMS FOR INTENSİVE CARE UNITS

Good design of ICUs provides comfort and security to patients or personnel and increase the success of treatment. Furthermore, it prevents the deficits that cannot be remedied later, and contribute renewing substructure of ICU in accordance to the current conditions.

The number of required beds of ICU should be determined according to the properties of the patients that planned to be interned, severity of the diseases, planned treatments to these patients, equipment that these treatments necessitate, substructure of these equipment, settlement of the beds and equipment, use plan, number, properties and comfort of personnel, necessity of other departments, sanitation and security etc[4, 5, 6, 7]. The number of the beds in ICU changes 4 to 50 based on the hospital and/or the service area's level. Large ICUs should be separated to sections that include 8-15 beds (1). According to the legislation of the Turkish Ministry of Health of country, an ICU should confirmed from minimum 4 beds, the ICUs that have under 10 beds should be organized as one service and the ICUs that have over 10 beds should be separated to sections which have 6-10 beds. In addition, each of the ICUs that have 6 beds should have an isolation room[8].

There are limited sources that describe the ICUs physical substructure and architectural design and it is usually difficult to access them. The well accepted source about intensive care design is the suggestions that published by Society of Critical Care Medicine in 1988. The relevant association and many other associations follow the most current edition of the Facility Guidelines Institute (FGI) guidelines for descriptive descriptions of the ICU. Australia and New Zealand have published their own current guidelines in Anesthesiology College.

LEVELS OF INTENSIVE CARE UNITS

ICUs College of Intensive Care Medicine of Australia and New Zealand (CICM) defines three levels of ICUs:

Level 1: This level provides CPR and short-term cardiorespiratory support to critical patients and plays role on preventing and following-up in medical or surgical complications. In this unit patients can be monitored for invasive cardiovascular follow-up and mechanical ventilation for a few hours.

Level 2: This level provides high standard intensive care service including complicated multi-system life support that promotes limited responsibilities of the hospital. This area should be minimum 6 bedded.

Level 3: This level is tertiary admission units for intensive care patients. It can provide comprehensive critical care including complicated multi-system life support for an undetermined time. This area might have over 50 beds which separated 8-15 bedded sections.

Pediatric ICU: This area has same properties as level 3 ICU and reserved for patients under the age of sixteen[1].

In our country, ICU leveling that is defined in "Communiqué on the principles and procedures of intensive care services in inpatient health facilities", is parallel to the definition of CICM[8].

PLANNING OF THE PLACE OF INTENSİVE CARE UNIT

ICUs should be near to emergency department, operating rooms, laboratory, department of radiology and elevators. In contrast, it should be far from the inpatient service visitors and other personnel. Moreover, it should enable to intern patients and perform medical or surgical treatments easily for patients and personnel. There should be extra ways that do not flow into the hospital traffic for easily going to mortuary and medical waste unit. If there should be multiple ICUs in the hospital, organization together of these ICUs as horizontal or vertical layout provides minimizing cost of construction and planning, in addition effective using of the sources like equipment, substructure, laboratory and personnel[8].

DESIGN

ICUs are compromised from 4 main areas that all have one primary function and/or a set of related functions.

1) Patient Care Area is compromised from patient rooms and adjacent areas. Its primary function is patient care.
2) Clinical Support Area is compromised from functions that closely related to directly patient care in all the areas of the unit, not only in patient's room.
3) Unit Support Area is compromised from administration, equipment and personnel support units.
4) Family Support Area is planned for supporting families and visitors[1].

The design of the unit starts with the deep analysis of patient care and support functions, workflow and policy of the hospital (visit times, participation of the families to patient care, etc.). It should be helpful to prepare a current and prospective equipment inventory. Clinical and Unit Support Areas promote clinical and administrative personnel directly. The design should be shortened the walking distance of the personnel and frequently needed area should be as near as possible to equipment or materials. While Family Support Area meets the needs of the visitors, it should not cause delay on patient's care. An efficient area should be small enough to allow caregivers to be fully aware of all the activities in the unit, but large enough to allow efficient staff work. Although a centralized or decentralized design is chosen, caregivers should be able to observe patients from multiple points within the unit.

There is no single ideal geometry for the placement of ICU. The published recommendations suggest units or patient room groups from at least six beds for efficiency and economy, and up to eight to 12 beds for observation reasons[1].

Patient care area: This place is defined as the patient rooms and adjacent areas that provides directly patient care service. Designers should consider needs of patients and visitors, and the care that given to patients directly by the personnel. To integration the families to daily patient care, family needs and care functions should be added to the design of ICU[9].

Single and multiple bedded rooms: researches have shown that single bedded rooms are better than multiple bedded rooms in terms of patient safety. In addition, it provides privacy to patients. Fully protecting rooms increase sleep quality, therefore it contributes to decreasing ICU delirium[1, 9, and 10].

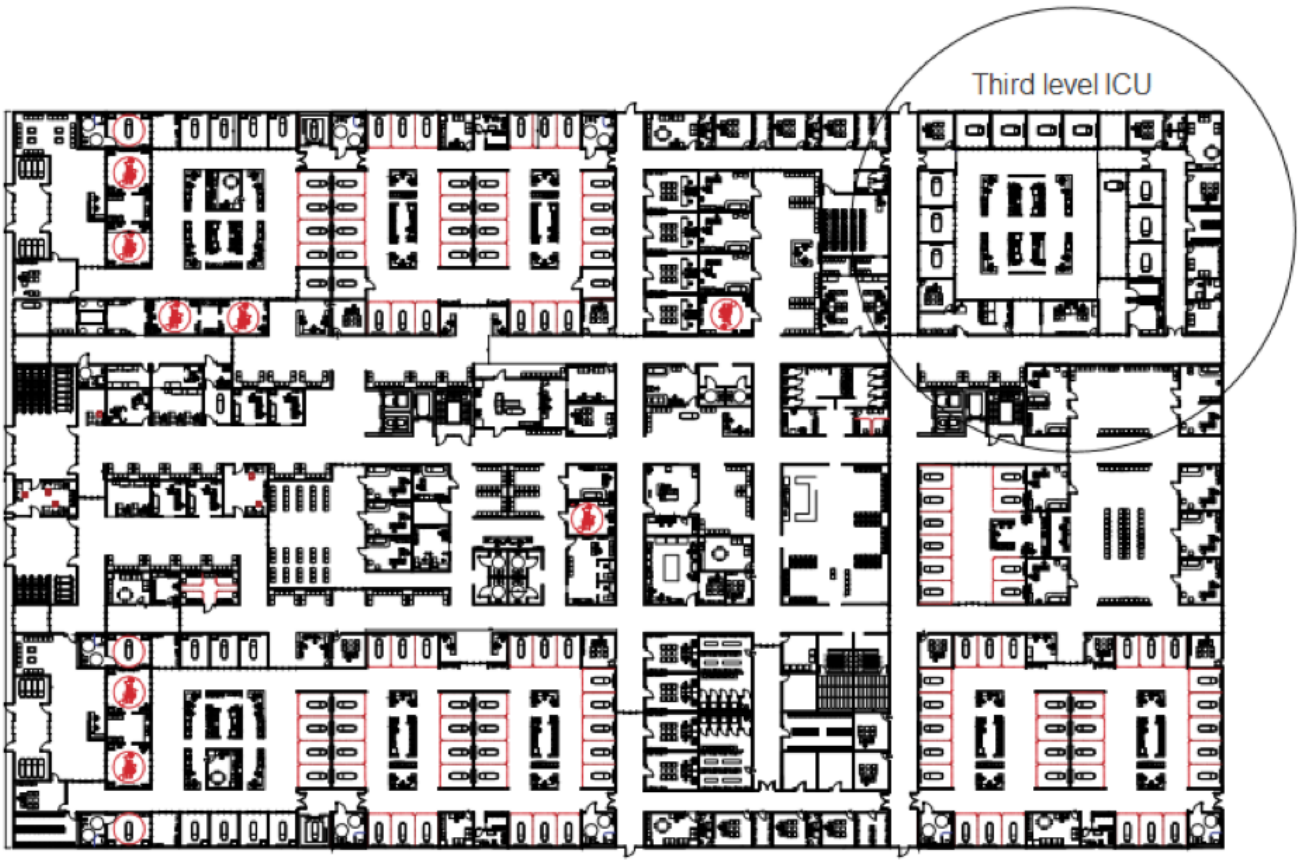
Clean surface areas: clean floor space represents unfilled area by the patient, fixed room furniture and equipment. The size of floor area should be enough for portable radiological imaging devices, echocardiography, electrocardiography (ECG), dialysis devices and more[9].

Patient area: There should be 20 m^2 floor area for each bed in an ICU, except the service areas and walking areas. For single bedded rooms this area should be minimum 25 m^2. In pediatric ICUs might have areas under 20 m^2 for baby cot. Each bed should have enough access (picture 4).

For every two beds there should be washbasin and faucet which can be on by elbow and foot. There should be at least one single room isolation procedure per six beds and each isolation room must have its own washbasin, bathroom and a front room of at least 3 m^2 and suitable facilities for insulation such as air flow control[1]. The Ministry of Health determined different measurements for our country. In adult ICUs, a minimum area of 12 m^2 is required for each bed, with a minimum distance of 1.5 m between the beds, except for support areas. Pediatric ICUs should have at least 12 m^2 of space for each bed so that the distance between the beds is at least 2 m, excluding support areas. Except for support areas, at least 6 m^2 of space should be reserved per neonatal intensive care bed, and for each incubator; 60 cm on the first level, 90 cm on the second level and 120 cm on the third level[8].

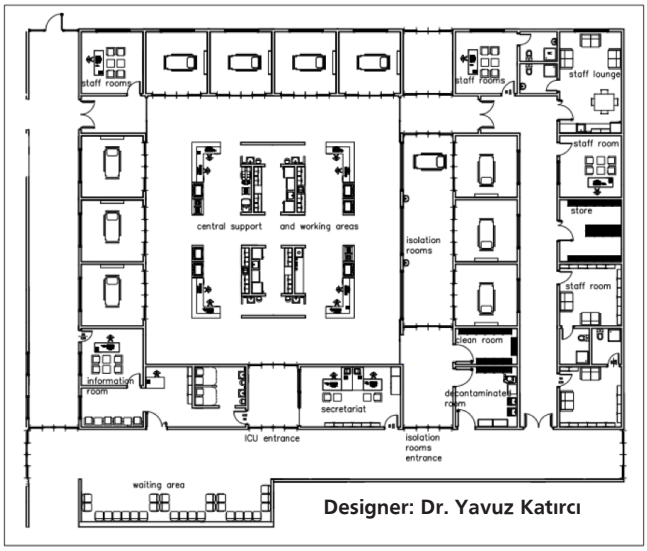
MEDICAL SERVICE DISTRIBUTION

System: The choice of systems for the installation and regulation of electricity, medical gas and other medical service

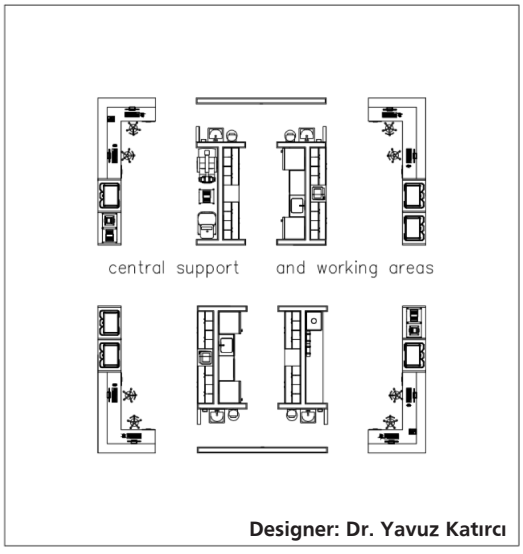


Picture 3. ICU in an experimental emergency room desing

Designer: Dr. Yavuz Katırcı



Picture 4. An experimental desing of third level ICU



Picture 4. An experimental desing of third level ICU working areas

organizations has a major impact on patient and staff satisfaction. Design team should consider patient type, functional plan, staff preferences, technology trends and potential future needs. All options must be considered for the installation and configuration of medical facility outlets. Combinations or hybrids of these systems might be suitable. The medical ancillary delivery system will have an impact on patient room placement and size. The bedside wall-mounted pendant configuration should be mounted on the wall at the head of the bed. This configuration is common, and it allows the outputs to be easily adjusted according to patient needs.

Column Configuration: This configuration should have a series of outlets on a vertical column of immovable attached to the floor and ceiling. The distribution of the outputs might vary depending on the needs of the receiver.

Boom Configuration: This configuration consists of a movable articulated arm(s). Ceiling-mounted booms provide maximum flexibility in positioning and accessing med-

ical gas, electrical and data outlets. In a third-level ICU, at least 4 oxygen, 3 air, 3 vacuum and 4 data outputs and 16 power points are required for each bed area. Accessory racks, brackets and poles can be mounted on these devices, enabling optimal positioning of all support devices such as monitors, computers, communication devices and intravenous (IV) pumps. The use of booms allows for maximum flexibility in beds placement [1, 9].

Medical Gas, Vacuum, Data and Electrical Sockets: These outlets should be accessible from both sides of the patient bed and arranged to provide enough space for multiple procedures at the same time. It is recommended that 50% of the electrical outlets in the patient room be connected to the hospital emergency power system. The oxygen system should be easily accessible during intubation or extubating procedures. In addition, face and aerosol masks should be accessible from both sides of the bed. Because some devices like ventilators use compressed air, enough space is required for additional medical compressed air outlets. There should be at least five vacuum outlets in each room for bronchoscopy, esophagogastroduodenoscopy and other bedside procedures, and for patients with multiple drains (such as chest tubes and wound drainages).

Patient rooms should be designed appropriate for computer terminals and mobile computer solutions. If a wireless system is not accessible, the data ports for the in-room computer terminals should be located so that clinical staff can monitor the patient during documenting or accessing patient information. The placement of computers should protect the confidentiality of patient data.

Adequate electrical outlets and space should be provided for pumps and IV bags to administer IV fluids and medicines. Most pumps are connected electronically to patient monitoring or data acquisition systems.

Drugs that are frequently or urgently needed should be available in or near the patient's rooms. Bedside drug storage should be in safe and keep large or one-dimensional products such as IV bags and large syringes. A computer-controlled distribution system can fulfill this requirement. To reduce staff travel, it should be conceivable to place a small refrigerator in patient rooms for medicines that need to remain cold, or to provide a central refrigerator for staff access to medicines.

Clean utility/workroom: Infection control is an important consideration and storage for clean and dirty products should prevent cross-contamination between the gastrointestinal and pulmonary tracts of visitors and staff and the patient. The design should have enough and suitable space to carry the linens during cleaning and dirty laundry should not be an obstacle. On the other hand, a clean, dry surface to stack clean linens should be added. Separate storage should be provided for clean and used gloves, aprons, hair coverings, shoe covers and eye protection (picture 4)[1, 9].

Doors: The door system should be sized to allow patients, bariatric beds, equipment and personnel to enter and exit patient rooms in the event of a crisis. Sliding glass doors that have opening capacity can provide more visibility to the patient as well as provide useful width.

Windows: Natural light is essential to the well-being of patients and staff and is required for most codes. Each patient care area should have at least one window of appropriate size per patient bed area that provides visual access to outside spaces. Window coverings should be easy to clean in accordance with infection control rules.

Providing patients with an external view - preferably facing the garden, courtyard or other natural environments - can help relieve anxiety and stress, improve care, improve patient comfort, and improve patient orientation. When a patient bed needs to look into the interior of the unit to be closely monitored by staff, an adjustable mirror mounted on the wall or ceiling can give the patient the appearance of the outdoor space.

Patient room furniture: critical care patient rooms should provide a hospital bed designed for a critical patient; a chair suitable for use by the patient and an additional chair for visitors (both cleanable); containers for collecting dirty laundry, garbage and waste products; and containers for collecting hazardous waste products such as needles and syringes.

To create a comfortable environment, rooms should have a clock, a calendar, and similar devices to allow patients and families to personalize the room. Greeting cards and photographs should be provided horizontal surfaces and placed for patients to see them.

The functional design of the unit should allow patient and family education. Therefore, appropriate materials should be provided to serve this purpose and give general information about the organization. Each patient room can be equipped with a television or training / entertainment system that can be controlled by the patient or family to support patient education as well as provide positive distraction and entertainment. In addition, the design should ensure safe storage of patient and family clothing[9].

Lighting system: Natural lighting should be provided as much as possible, and the presence of windows ensure the day-night orientation of the patients. Fire resistant, easy to clean, antibacterial curtain systems are suitable for windows. The parts of the unit without natural lighting should be illuminated at night by using indirect and soft light. According to the standards of the Turkish Ministry of Health, general lighting is preferably set to be 20 fc or 215 lux, spot lighting is 150 fc or 1600 lux[8].

Climatization: In consultation with the care team, patients and families should be able to control the room temperature.

Communication system: The ICU should have in-unit, in-hospital and out-of-hospital telephone facilities, an intercom system to communicate between the sub-units of the ICU, and an in-unit alarm system.

Monitoring system: There should be monitoring resources for measurements of ECG, invasive pressure mea-

surement, direct or indirect arterial oxygen level measurement, pulse oximetry or pO_2, tidal CO_2, transcutaneous pCO_2, temperature, thermodilution cardiac output (CO) measurement, noninvasive CO measurement, mixed venous O_2 saturation measurement, electroencephalography (EEG), mass spectrometry, respiratory mechanics measurement, somatosensory evoked potentials (SEP). Moreover, all these devices' substructure should comply with standards.

Laboratory: ICUs should have access to 24-hour clinical laboratory services. These can be provided by a central hospital laboratory or a satellite laboratory within or near the ICU. If satellite facilities are used, they should provide minimum chemistry and hematology testing, including arterial and mixed venous blood gas analysis. If blood gas analysis is common in the unit, an area for a blood gas analyzer can be included in the overall design. With the increasing prevalence of drug-resistant pathogens, samples should be stored carefully and separately from patients in isolation rooms. Pneumatic tube systems can be used to transport samples quickly to the laboratory[8].

Imaging: Imaging services should be easily accessible by the ICU. The unit should provide enough storage for portable imaging machines. The patient archive communication system and a reading room with digital display with movie display boxes and / or high-resolution displays should be located inside or near the unit[8].

Nurse Desk Unit: The nurse desk, where the central monitoring and monitoring unit is located, should also be designed for intensive care workers and patients to see each other. It is usually made in the middle or side of the area where the patient beds are located. At the nurse desk; central monitors, intensive care data management system, hospital accruals and laboratory connections for computer, printer, telephone, gas and vacuum system pressure indicators and their alarms should be available. Adequate space and systems should be available for the organization and storage of patient follow-up forms, observation of personnel by the ICU supervisor and shift changes (picture 5)[1, 8].

SUPPORT AREAS

Clean and Contaminated Materials Rooms: The ventilation of the contaminated material room should be separated, and the contaminated air must be exhausted. Clean and sterile materials should be stored in the clean room and the ventilation of the room should be provided with sterile air supplied from air conditioning. There should be a enough shelves and / or cupboards and be at a height above the floor. This storage area should be 20 m^2 with washbasins, hot and cold water, buckets for medical waste and special waste bins for sharp-penetrating medical waste (picture 4). In the dirty material room, there should be a drain and washing device for sanitizing the bedpans. If the dirty room is large enough, medical waste should be placed in the waste container or stored in a separate waste room. The waste room should be 2-3 m^2 and designed in accordance with the medical waste instructions.

Personnel Support Room: ICU staff need places to sleep, eat, relax, take care of personal needs and store their belongings. Short sleep or sleep breaks can help medical personnel work better and reduce errors. Telephones or intercom systems should connect these rooms to the ICU and cardiac arrest/emergency alarms should be audible. In addition, computer access to patient medical records and image archiving and communication systems would be ideal. And of course, toilet and shower facilities should be provided.

There should be a common room where ICU employees can relax except sleep. A staff lounge in or near the intensive care unit provides a special, comfortable, spacious and relaxing environment. The lounge should have a comfortable seating area, a table with chairs for meals, and food storage and preparation facilities, including a large fridge, microwave and coffee dispenser or coffee machine. The room must be separated from the common areas. If possible, windows that open outdoors should face nature. The hall should be ventilated to remove food odors from patient care and public areas.

Staff Toilets: Toilets designed to meet clearly defined and accessible requirements for staff should minimize time away from duty but ensure confidentiality. Toilets should not be opened directly to the staff lounge. If the unit is large or contains several capsules, more than one personnel toilet should be considered. Separate men's and women's toilets are recommended, and each toilet should include hand wash basin, dispensers for soap and dehydrated hand cleaner, hand dryers, waste container and mirror. A storage cabinet and shelves should be helpful.

Cabinets: A secure area for lockers for staff items should be found inside or near the staff room. In larger facilities, these areas may be designated for different sections of staff or shared by multiple units. As many nurses or other staff may choose to keep certain items on the workstations, designers should consider providing safe drawers or shelves in these places[8].

Information Desk: There should be a reception area to check visitors' access to the unit, provide information and, if necessary, prevent entry. This zone should preferably be located at a location different from the personnel entrance, connected to the other parts of the intensive care unit with telephone and / or closed-circuit television system.

Visitor Waiting Room: this room should be placed in an area that the receptionist can control check-in and out. There should be 1-2 seats for each patient bed. There should be telephone, television, music and toilet. Indirect lighting should be provided, if possible, there should be windows, and be painted in warm colors. There should be a small space in this room/connected to the room where families can be given special information about their patients[1, 8].

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