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Nosocomial Pneumonia in Medico-Surgical Intensive Care Unit

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Cases of hospital acquired pneumonia occurring during the 1st 12 months of Medico-Surgical ICU (Intensive care unit, MSICU) in operation were evaluated retrospectively to determine its incidence, common causative pathogens, outcome and radiological patterns with the new hospital setting providing a unique relatively aseptic environment. Among the 920 admitted patients, 73 episodes of nosocomial pneumonia on 63 patients were identified and the incidence rate was 7%. The most common pathogens were Pseudomonas, Staphylococcus, Serratia, and Enterobacter in the order of frequency of occurrence, and the gram-negative pathogens comprised 70%. Nocomial pneumonia was more common after use of antibiotics due to such pathogens as Enterobacter, Acinetobacter, and Candida which caused poor outcome. Enterobacter had the greatest tendency to be related with poor outcome and Serratia the least. Overall mortality was 25%. Bronchopneumonia was the most common type of pneumonia caused by any pathogen except Acinetobacter which caused a mixed type of nosocomial pneumonia.

Key Words: *MSICU (Medico-Surgical Intensive Care Unit), Nosocomial pneumonia, Pathogen*

INTRODUCTION

Intensive case units (ICU) are equipped with up-to-date facilities and staffed by meticulously trained personnel to minimize hospital acquired infection. In spite of this, nosocomial infections of the respiratory tract are frequent and difficult to prevent. Graybill et al. (1973) reported the infrequent documentation of the diagnosis in patient discharge summary reflecting the difficulty also in diagnosis. Therefore, knowledge on the pathogenic trends of nosocomial pneumonia at ICU is essential for the patient care and correlation of the radiological findings with the pathogens would be an aid to the clinicians in making the diagnosis.

The new hospital setting providing a unique advantage to observe the trends of nosocomial pneumonia in an relatively aseptic environment (and related added advantage in long-term sequential follow-ups), a retrospective study during the 1st 12 months of operation of MSICU was performed to determine incidence, causative pathogens, outcome and radiological patterns on plain films so that these data would enable the evaluation of subsequent possible preventive measures.

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MATERIALS AND METHODS

During the 1st year of its medical service from May 24th, 1989 to May 23rd, 1990 the MSICU at Asan Medical Centre was able to capacitate 26 patients at any time, with the average bed occupancy during the one year period being 20 per day, the average bed space being $12m^2$/bed, with a nurse to patient ratio of 3:1. 206 patients showed positive blood or respiratory aspirate culture among 920 patients admitted to MSICU on 944 occasions over the 1 year period. Out of the 206 patients, a retrospective study was performed on 196 whose charts were available. The criteria we used for the diagnosis of nosocomial pneumonia were adapted from those by Tillotson et al. (1969). They

were: (1) fever>38.5°C, (2) WBC>10,000/mm^3 or <3,000/mm^3, (3) clinical symptoms and signs such as purulent sputum, dyspnea, rale, etc, (4) presence of a new or progressive infiltrate on chest films, and (5) positive pathogen on any combination or repetition of blood, sputum, bronchial/tracheal aspirate, and pleural fluid cultures. (*Candida* was considered as a causative pathogen if isolated from blood culture or clinical improvement resulted after using Amphotericin B. Organism isolated from sputum culture was considered for the possibility as a causative organism if there were >25 leukocytes and <5 squamous epithelial cells per low-power field on smear. Bacterial reports of "rare" or "few" (ten or less) colonies of an organism on culture were ignored and cases with "moderate" or "many" colonies were considered.)

Cases were excluded with some discretion if there was concurrent Adult Respiratory Distress Syndrome (ARDS), congestive heart failure, or pulmonary embolism making radiological evaluation rather difficult, and were excluded if negative pathogen on culture, negative findings on chest films, or if there was no change on the films. Therefore, cases with a pathogen positive only once on culture and some cases with mild concurrent diseases were not excluded and were only said not to satisfy the 4th and 5th criteria respectively.

Categories of nosocomial pneumonia used in this study were the modifications of those by Cross et al. (1981) and by Papazian et al. (1989). Thereby, cases were classified to be "definite nosocomial" if all the criteria were satisfied, "apparent nosocomial" if one criterion was not satisfied, "probable nosocomial" if two criteria were not satisfied, "possible nosocomial" if three criteria were not satisfied, "not nosocomial" if more than three criteria were not satisfied or if any criterion was positive within 48 hours after admission, and "no pneumonia"if there was no apparent evidence for pneumonia. Only the cases classified as "definite nosocomial", "apparent nosocomial", and "probable nosocomial" were considered to be the cases with nosocomial pneumonia. Nosocomial pneumonia was considered to be primary if occurring before the use of antibiotics and secondary thereafter.

Multiple episodes of nosocomial pneumonia were possible in each case.

Table 1. Categories of Nosocomial Pneumonia with corresponding number of criterion

Pneumonia	Definition	Case
Definite nosocomial	(all criteria satisfied)	29
Apparent nosocomial	(1 criterion unsatisfied)	22
Probable nosocomial	(2 criteria unsatisfied)	12
Possible nosocomial	(3 criteria unsatisfied)	28
Not nosocomial	(>3 criteria unsatisfied or criteria occurring<48 hrs after admission)	80
No pneumonia	(no evidence of pneumonia)	25
Total		196

Table 2. Episodes of primary and secondary Nosocomial Pneumonia in relation to Pathogenic Combination

	Combination		
	Single*	Mixed**	Total(%)
Primary	9	2	11(15%)
Secondary	33	29	62(85%)
Total(%)	42(58%)	31(42%)	73***

* Most of the episodes had more than one pathogen cultured. Therefore, "single" pathogen means single "main" pathogen cultured more than once with other accompanying pathogens cultured only once being excluded from the category of "main" pathogen.

** "Mixed" combinations include 2 episodes of primary nosocomial pneumonia and 29 episodes of secondary: 2 episodes of primary are composed of 1 episode each of double and triple combinations while 29 episodes of secondary are composed of 26, 2 and 1 episodes of double, triple and quadruple combinations respectively.

*** Total number of pneumonic episodes.

RESULTS

Among the 196 patients on whom the retrospective study was performed, 171 patients has clinical pneumonia and out of these 80 has non-nosocomial pneumonia and 63 had nosocomial pneumonia as shown in Table 1. Therefore, since 920 patients were admitted to MSICU during the first year of MSICU in operation the nosocomial pneumonia acquisition rate was calculated to be 7%.

Causative pathogen was isolated from repeated sputum cultures taken on different days in 34 episodes, from blood cultures in 6 episodes, from tracheal or bronchial aspirate cultures in 4 episodes, and from pleural aspirate cultures in 1 episode. Blood and sputum cultures taken about the same time revealed causative organism in 16 episodes and among these, identical pathogens were isolated on both cultures in 12 episodes giving arise to pathogenic concordance rate of 75%. Sputum and tracheal or bronchial aspirate cultures isolated organism in 8 episodes out of which 7 episodes showed identical pathogens resulting in concordance rate of 80%. Blood and tracheal or bronchial aspirate cultures showed identical pathogens in 2 episodes. Sputum and pleural fluid were cultured in 1 episode revealing identical pathogens. Sputum, blood, and tracheal or bronchial aspirate were cultured in 2 episodes and identical pathogens were isolated in 1 of the episodes.

Among the 73 episodes of 63 cases of nosocomial pneumonia, single pathogen was responsible for 42 episodes (58%) of which *Pseudomonas, Staphylococcus, Serratia,* and *Acinetobacter* were responsible for 11, 7, 6 and 4 episodes respectively as shown in both Tables 2 and 3. *Streptococcus, Candida, Serratia,* and *Acinetobacter* appeared as single responsible pathogens in 50, 50, 46 and 44% (Table 3). Primary nosocomial pneumonia accounted for 15% and secondary 85%. As the main pathogen, *Pseudomonas, Staphylococcus, Serratia,* and *Enterobacter* were common in 24, 17, 12 and 9% respectively. Gram-negative pathogens accounted for 70% which was higher than the 53% reported by Eickhoff et al. (1969). Gram positive cocci was 24% and fungus 6%.

Mixed pathogens were responsible for 31 episodes (42%) and, among them, double pathogens were responsible for 27 episodes (87%) of which *Pseudomonas* and *Klebsiella, Staphylococcus* and *Serratia, Pseudomonas* and *Candida, Pseudomonas* and *Streptococcus, Pseudomonas* and *Proteus,* and *Staphylococcus* and *Enterobacter* combinations were common in 3, 3, 2, 2, 2 and 2 episodes respectively. *Pseudomonas* acted most commonly as one member of a double combination in 15 out of 27 episodes.

Patients with underlying neurologic causes for nosocomial pneumonia comprised 59% (Table 4) and, among these SAH (Subarachnoid Hemorrhage), AVM (Arterio-venous Malformation) and ICH (Intracerebral Hemorrhage) comprised 54%. Among the patients with neurologic underlying diseases 32% either deteriorat-

Table 3. Incidences of Pathogenic Organisms in relation to Pathogenic Combination

	Combination		
	Single(%)	Mixed(%)	Total(%)
Pseudomonas	11(42)	15(58)	26(24)
Staphylococcus	7(39)	11(61)	18(17)
Serratia	6(46)	7(54)	13(12)
Enterobacter	3(30)	7(70)	10(9)
Klebsiella	3(33)	6(67)	9(8)
Acinetobacter	4(44)	5(56)	9(8)
Streptococcus	4(50)	4(50)	8(7)
Candida	3(50)	3(50)	6(6)
E. coli	1	3	4(4)
Proteus	0	3	3(3)
H. influenzae	0	2	2(2)
Neisseria	0	1	1(1)
Total	42	67	109(100%)**

** Total number of episodes each main pathogen was cultured. Since two or more pathogens were isolated during one episode in some patients, this number is greater than the 73 total episodes mentioned on Table 2.

Table 4. Relationship between Underlying Disease and Episodes of Deteriorated or Expired Outcome

	Outcome		
	SI*	DE**	Total
Neurologic			
SAH/AVM/ICH	11	9	20
Infarct	7	1	8
Sepsis☆	2	2	4
Other☆☆	5	0	5
Total	25(68%)	12(32%)	37
Non-neurologic			
Sepsis▫	1	7	8
Malignancy▫▫	1	3	4
Other▫▫▫	8	6	14
Total	10(38%)	16(62%)	26
Total	35(56%)	28(44%)	63†

* Stationary or Improved Outcome

** Deteriorated or Expired Outcome (cases with the deteriorated outcome represent hopelessly discharged cases)

† Total number of Nosocomial pneumonia cases

☆ Sepsis with ICH, infarct, and lupus encephalitis

☆ Cervical spine fracture, Guillain-Barré syndrome, meningioma, and astrocytoma

▫ Sepsis with diabetic nephropathy, hepatic encephalopathy, septic cholangitis, traumatic pancreatitis, splenic rupture, duodenal ulcer bleeding, and gastric cancer perforation

▫▫ Primary lung cancer, metastatic lung cancer, and prostatic cancer with metastasis

▫▫▫ Myocardial infarct, femoral artery rupture, epidemic hemorrhagic fever, carbon-monoxide poisoning, and tetanus

Table 5. Pathogenic Episodes of Deteriorated or Expired Outcome per Underlying Causes

	Underlying Causes			
	Neurologic	Non-neurologic	All	All/Total
Pseudomonas	4(25%)*	7(70%)*	11(42%)**	26%
Staphylococcus	3(35%)	2(33%)	5(34%)	12%
Serratia	2(24%)	1(50%)	3(29%)	7%
Enterobacter	3(60%)	2(100%)	5(71%)	12%
Klebsiella	1(25%)	1(50%)	2(33%)	5%
Acinetobacter	2(44%)	2(100%)	4(62%)	9%
Streptococcus	3(60%)	0(0%)	3(43%)	7%
Candida	1(50%)	3(75%)	4(67%)	9%
E. coli	1	1	2	
Proteus	1	1	2	
H. influenzae	0	0	0	
Neisseria	1	1	2	
Total			43	

* Deterioration or Expiration rate of the patients with the underlying cause and the responsible pathogen for the nosocomial pneumonia.

** Deterioration or Expiration rate of the patients with any underlying causes and the responsible pathogen for the nosocomial pneumonia.

Table 6. Distribution of pathogens according to the types of pneumonia

	Types of Pneumonia				
	Lobar	Broncho	Interstitial	Mixed	Total
Pseudomonas	3	11	5	7	26
Staphylococcus	1	8	4	5	18
Serratia	2	6	2	3	13
Enterobacter	2	3	2	3	10
Klebsiella	1	3	2	3	9
Acinetobacter	0	3	2	4	9
Streptococcus	1	3	2	2	8
Candida	1	4	1	0	6
*Others**	1	4	2	3	10
Total	12(11%)	45(41%)	22(20%)	30(28%)	109

* *E. coli, H. influenzae, Proteus,* and *Neisseria.*

ed or expired, and nosocomial pneumonia with underlying SAH, AVM, or ICH was the cause in most of these (75%). Patients with non-neurologic underlying causes comprised 41% and, among these sepsis comprised 31%. Among non-neurologic patients 62% either deteriorated or expired and nosocomial pneumonia with underlying sepsis was the cause in most of these (44%). 75% of the patients with sepsis as a major and minor underlying disease either deteriorated or expired and the mortality rate was 44%. Overall, 44% of the patients with nosocomial pneumonia with various underlying causes either deteriorated or expired and the mortality rate was 25%.

As shown in Table 5, *Pseudomonas, Staphylococcus* and *Enterobacter* were the most common responsible pathogens for the nosocomial pneumonia of the patients with worsening of condition in 26%, 12% and 12% respectively. *Enterobacter, Candida* and *Acinetobacter* showed the greatest tendency to appear in the patients with worsening of condition in 71%, 67% and 62% respectively occurring only after antibiotics use. Interestingly 3 cases with triple and quadruple pathogenic combinations were all related to sepsis and the patients all expired.

Table 5 shows that for cases with underlying neurologic causes *Enterobacter* and *Streptococcus,* and for cases with non-neurologic causes *Enterobacter, Acinetobacter, Candida* and *Pseudomonas* showed the greatest tendency to appear in patients with worsening of condition. For septic cases, *Pseudomonas* and *Candida* had a 100% and a 86% rate of tendency to appear in the patients with either deteriorated or expired outcome respectively.

Bronchopneumonia with an incidence of 41% was the most common type of pneumonia caused by any pathogen except *Acinetobacter* which caused more Mixed types of pneumonia (Table 6).

Legends for Figures

Fig. 1. *Pseudomonas* Bronchopneumonia.
63 year old male with acute respiratory failure.
a. Chest PA taken 2 weeks later showed haziness at right central lung field suggesting pulmonary congestion.
b. 3 days later, disseminated multifocal patch consolidation was noted.
Pseudomonas was isolated repeatedly from sputum.

Fig. 2. Consecutive *Staphylococcal* and *Enterobacter* Lobar pneumonia and *Serratia* Bronchopneumonia. 20 year old male with cerebral contusion.
a. 2 weeks after the admission, chest PA showed homogeneous consolidation at right lower lobe. *Staphylococcus* and *Enterobacter* were isolated from blood.
b. Pneumonia improved after antibiotics treatment for 1 week.
c. 1 day later, patient's condition deteriorated and chest PA showed multiple confluent patch consolidation on both lung fields. Blood culture revealed *Serratia.*

Fig. 3. *Staphylococcal* and *Enterobacter* Bronchopneumonia. 42 year old male with hepatic encephalopathy. Chest PA taken 6 days later showed granular ground-glass like consolidation of right middle and upper lobe. *Staphylococcus* and *Enterobacter* were isolated from blood culture.

Fig. 4. *Staphylococcal* and *Candidal* Bronchopneumonia. 52 year old male with duodenal ulcer bleeding. 10 days after admission, a focal consolidation was noted at the anterior segment of the right upper lobe. Patch consolidations were also seen in both lower and upper lung fields. Sputum culture revealed *Staphylococcus* and *Candida.*

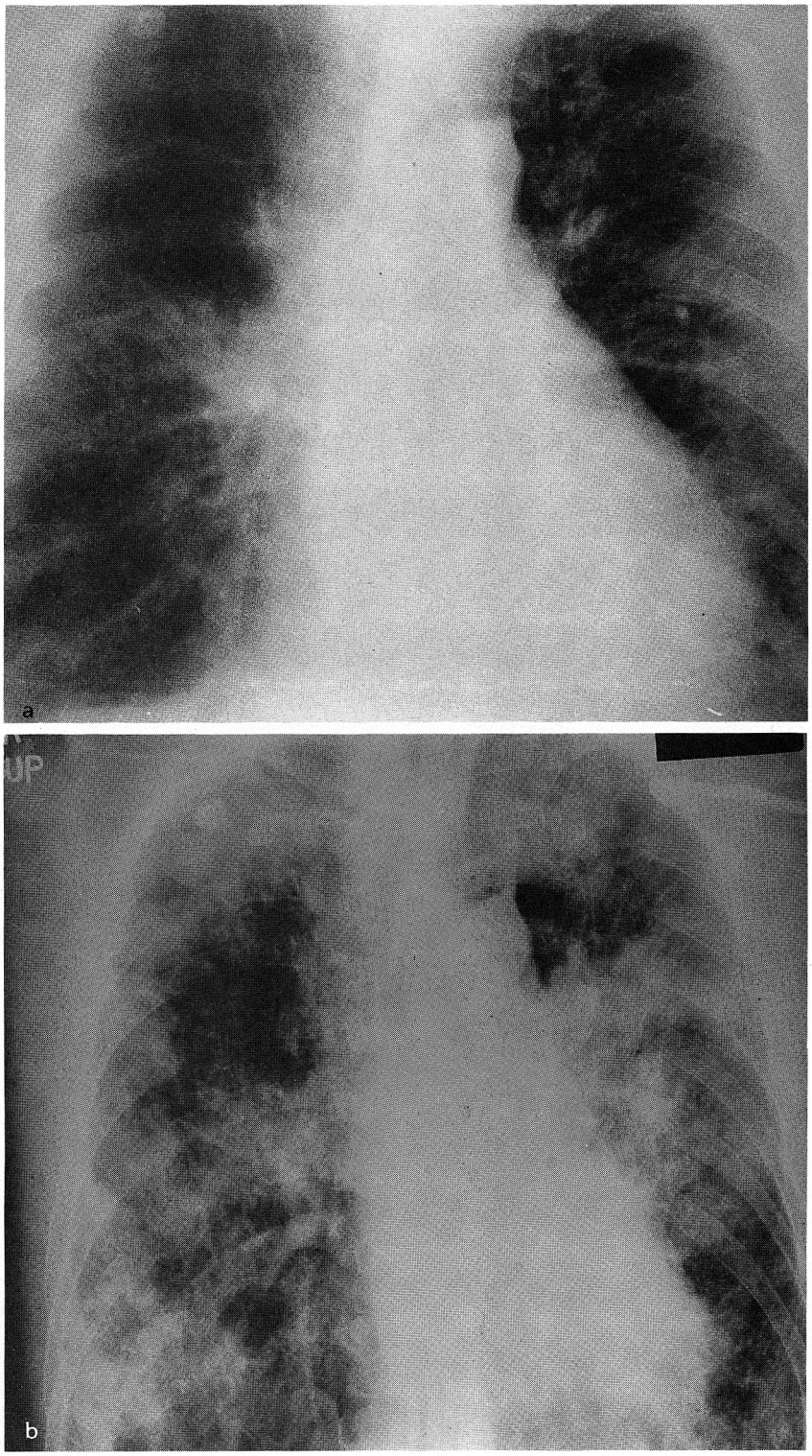

Fig. 1

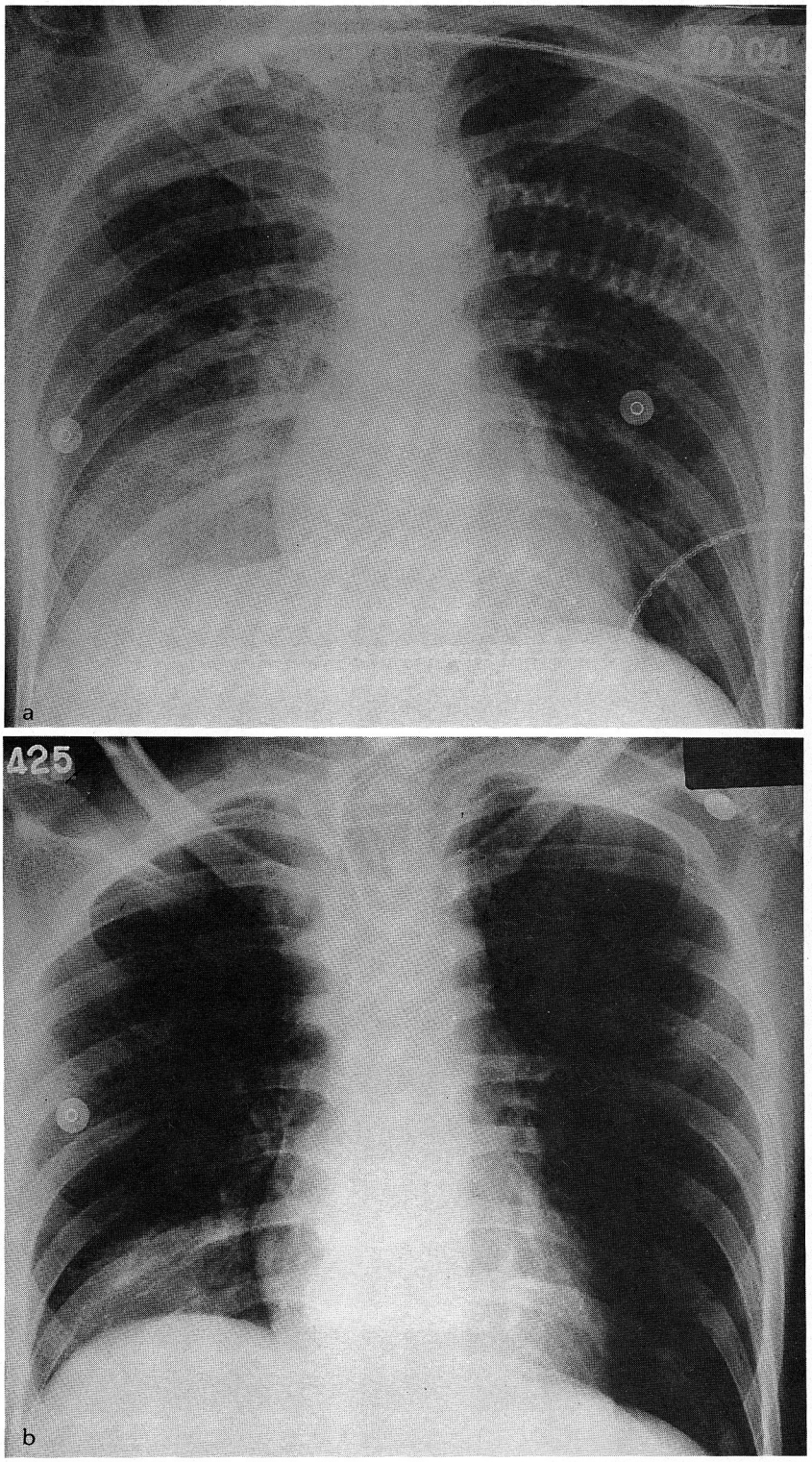

Fig. 2

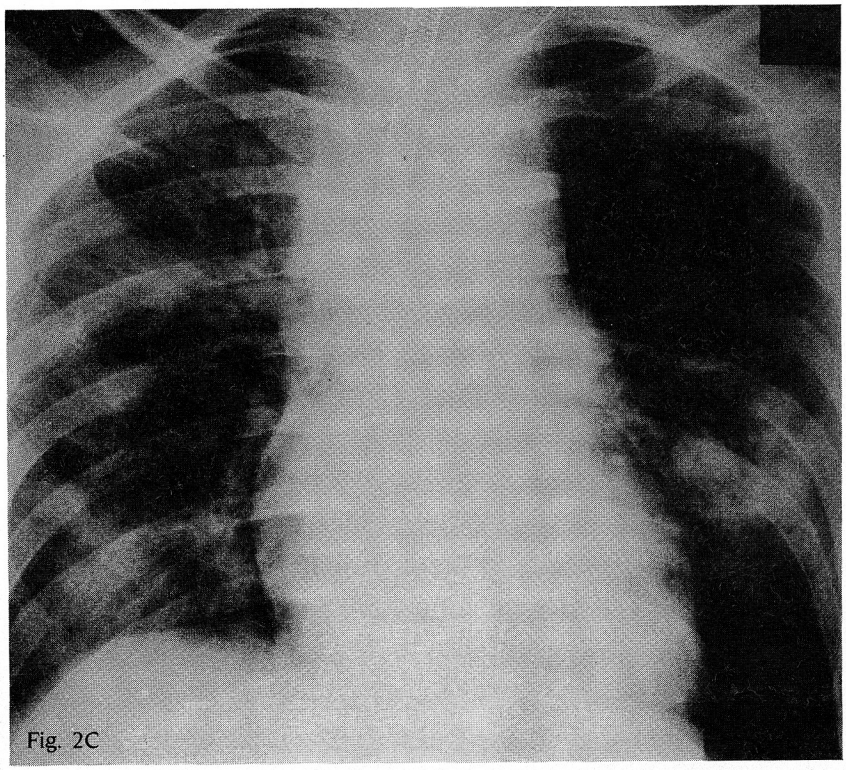

Fig. 2C

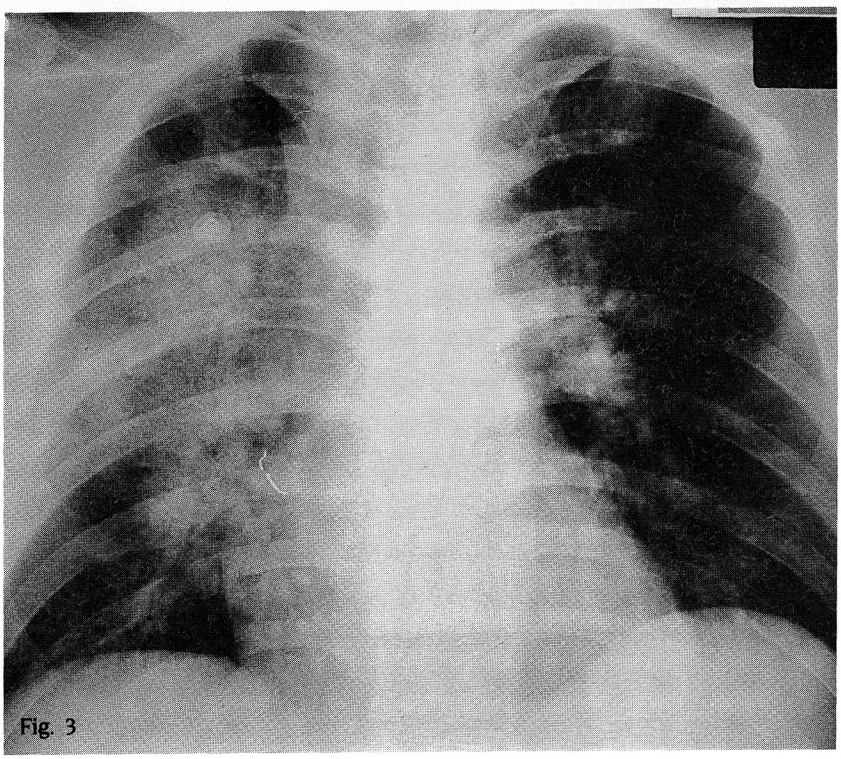

Fig. 3

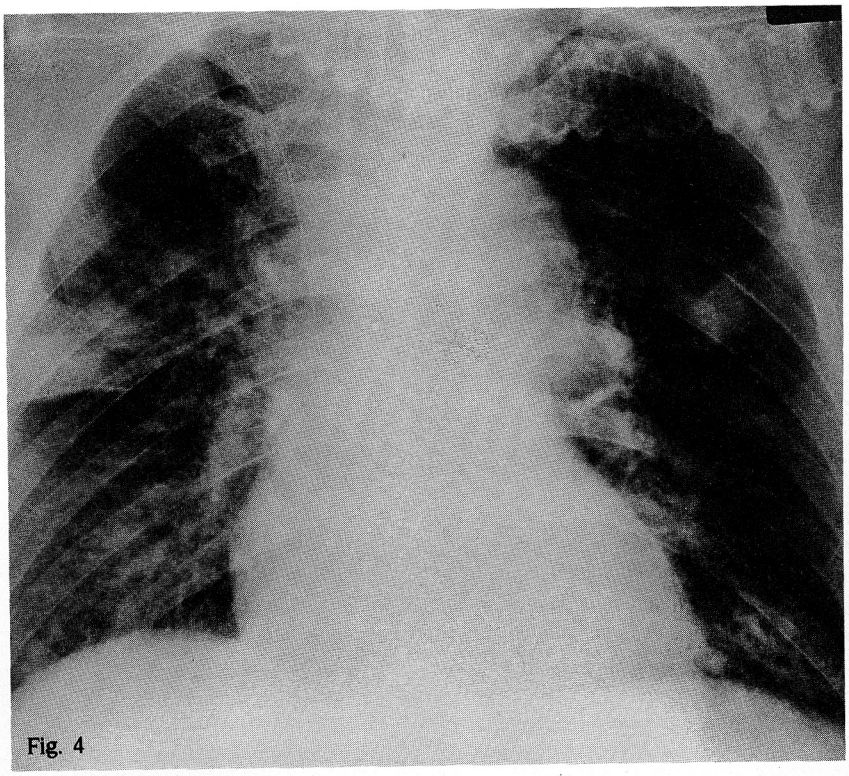

Fig. 4

DISCUSSION

The nosocomial pneumonia acquisition rate in ICU's is reported to vary from 10% to 20% (Stevens et al. 1974; Johanson et al., 1972; Potgieter et al., 1987), and that in hospital from 1% to 10% (LaForce, 1981; Pierce et al., 1974) in most previous studies. This variation is due to the different criteria set for each study to determine nosocomial pneumonia. The criteria used for this study allowed some flexibility such that some cases with WBC or a fever slightly lower than the values set by the criteria, and cases with pathogen positive on culture only once or with radiologically not so clear-cut changes but with all other evidence pointing towards nosocomial pneumonia could be included. There were no cases without the typical symptoms and signs of a nosocomial pneumonia. Our low nosocomial pneumonia acquisition rate of 7% might be due to a relatively strict application of the criteria, the fact that this study was done in ICU of a new hospital setting, and the exclusion of cases with any criterion occurring within 48 hours after admission (Potgieter et al. (1987) using a 24 hr exclusion criterion reported a 23% acquisition rate).

The most common main pathogens were *Pseudomonas, Staphylococcus, Serratia,* and *Enterobacter* in order of decreasing incidence. In any case, main pathogens might consist of either single or mixed pathogens. *Serratia, Candida* and *Streptococcus* had the greatest tendency to occur as a single pathogen, whereas *Klebsiella* and *Enterobacter* showed the least tendency.

Mixed pathogens were responsible for 42% of the cases and this is quite compatible with the findings of Jimenez et al. (1989). This suggests that in half of all the episodes radiologic patterns might be mixed, but this can not be so since the mixed type of nosocomial pneumonia occurred in 28% as shown in Table 6. Double pathogens comprised most of the mixed pathogens such as *Pseudomonas* and *Klebsiella, Staphylococcus* and *Serratia,* and *Staphylococcus* and *Enterobacter* combinations. Double combinations are also quite evenly distributed among various pathogens so there might not be much indication of which were the most or the least common combinations except to say that the common double pathogens also consisted of the common main pathogens. It is interesting to note that the triple and quadruple cases were all related with sepsis and that the patient all expired. This might be related to the poor immunity that septic patients are prone to develop.

Most of the cases had secondary nosocomial pneumonia and this implies that the use of antibiotics increases the chances of acquirring nosocomial pneumonia by changing normal flora (Sanford et al., 1979; Dixon, 1983) and, that usually antibiotics are used as soon as patients are admitted. *Candida, enterobacter,* and *Acinetobacter* appeared only as secondary nosocomial pathogens.

Patients with underlying neurological causes were more prone to acquire nosocomial pneumonia (59%) in comparison to patients with non-neurologic underlying causes (41%), since mental state change is related frequently to inadequate self-respiration, mechanical ventilators, and aspiration pneumonia (Dixon, 1983). Among them, SAH, AVM and ICH were the most common and their outcomes were severe.

Even though, the incidence of nosocomial pneumonia was not as frequent as in the patients with neurologic underlying causes, patients with underlying non-neurologic causes resulted in a worse outcome more often due to sepsis which caused 44% of the incidences of worsened outcome. It can be said that the outcome of a nosocomial pneumonia patient would be worst with underlying sepsis.

26% of the pathogens responsible for nosocomial pneumonia of the patients with worsened outcome were due to *Pseudomonas* and this figure matches quite well with 24% of the main pathogens being *Pseudomona.* For *Staphylococcus* and *Serratia* it is significant to note that their 12% and 7% rates of being related with worsened outcome as causative pathogens for nosocomial pneumonia are less than the 17% and 12% composition rates of main pathogens. Whereas for *Candida* the 9% rate of being related with a worsened outcome is greater than the 6% composition rate of main pathogens. From these, although it can not be said that there was a direct correlation between the pathogens and outcomes and that the outcomes of *Pseudomonas* and *Streptococcus* would be moderate, those for *Staphylococcus, Serratia* and *Klebsiella* better, and those for *Enterobacter, Acinetobacter* and *Candida worse, at the same time emphasizing more of the underlying diseases for the outcome, it can be said that some pathogens might tend to occur in certain patient conditions, might contribute to such conditions more than others, or both. Enterobacter, Acinetobacer,* and *Candida* causing secondary nosocomial pneumonia only in the patients with poor outcome might suggest that they occur in long debilitated patients with a poor condition. While the degree of pathogenic contribution on outcome is unknown in this study, with the tendency of the pathogens to appear in certain patient conditions as shown, it can be said that the worst outcome might be expected with *Enterobacter* and the best outcome with *Serratia.*

Correlation of outcome with underlying causes and pathogens, in hospital setting as a whole or for certain diseases in ICU, could be done using such methods as the criteria of McCabe and Jackson (McCabe et al., 1962) which, in the opinion of the authors, is inappropriate for nosocomial pneumonia in ICU due to the complexity and the multiplicity of the diseases and other factors manifestating in each patient, the tendency of multiple pathogens to appear, and further most the difficuly of diagnosing nosocomial pneumonia. Other methods such as APACHE (Acute Physiology and Chronic Health Evaluation; Knaus et al., 1981) system could be of value instead and future studies on ICU nosocomial pneumonia utilizing these could give better assessment of outcome, underlying disease, and pathogen.

Overall, 44% of nosocomial pneumonia cases either deteriorated or expired and the mortality rate was 25% which is lower than the 38% reported by Jimenez et al. (1989).

Bronchopneumonia was the most common type of nosocomial pneumonia and not surprisingly the Mixed type of pneumonia was close behind (Table 6).

SUMMARY

The nosocomial pneumonia acquisition rate in the MSICU was 7% and the most common causative pathogens were *Pseudomonas, Staphylococcus, Serratia,* and *Enterobacter* in both single and mixed infections. Secondary nosocomial pneumonia was more common. *Enterobacter, Acinetobacter* and *Candida* caused secondary nosocomial pneumonia only and had the greatest tendency to appear in the patients with a poor outcome while *Serratia* had the least. 44% of nosocomial pneumonia cases resulted in a worsened outcome with the mortality rate of 25%. Bronchopneumonia was the most common type of nosocomial pneumonia in 41%.

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