THE CLINICAL ENGINEERING PROGRAM IN NTUH

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ABSTRACT

CLINICAL ENGINEERING is an interdisciplinary science. It has several breadths in its interfacing practices among healthcare delivery system that include (1) specific engineering supports to clinical specialties, (2) hospital system engineering programs, (3) managerial integration based on biomedical engineering practices, (4) safety and performance assessment of medical devices, and (5) compliance with specific regulations and standards. Each breadth requires highly integrated interdisciplinary principles to fulfill its professionalism. These are different professions based on academic biomedical engineering principles and healthcare principles. This clinical engineering practical training program is designed to fulfill the requirement of human resources for the advanced biomedical engineering applied and practiced in hospital environments.

INTRODUCTION

The professionalism of clinical engineering[1,2] is characterized as the interface between hospital device applications and academic biomedical engineering principles or sophisticated technical resources supports. In the application domains of sophisticated medical devices in modern hospitals, there exist the likelihood of hidden problems such as the cost-effectiveness, the interfacing technology of device implementation, the quality assurance procedure, and the safety and performance of their procured medical devices, etc. Nonetheless, all of these technologies of application or operating interface can not only provide a modern hospital with the practical technology management but also perform the cost and quality medical cares, only if it can be systematically integrated and procedurally quality controlled. A clinical engineering training program must

provide a hospital practiced biomedical engineer or technician with system integration technique and technical talents of clinical field equipment's. With this approach, a potential CLINICAL ENGINEER is capable of independent and aggressive involvement in the hospital technology management and fulfills the "technical bridges" between biomedical engineering principles and medical device related professions.

CONCEPTUAL APPROACH TO HOSPITAL SYSTEM

The clinical engineering attributes its discipline-integration among medicine, engineering, and administration within medicine and hospital system. In addition, clinical engineering merges both vertical (characterized as clinical specialty integrity) and horizontal (characterized as hospital wide integrity) technical attributes into its integral discipline. Thus, the training should stress on its technical disciplines in clinical fields and extend related biomedical engineering principles to the applied fields. Actually, the vertical technicalities or the clinical fields in hospitals involve in several professional disciplines that can be classified as (1) Biomechanics, (2) Biomaterials, (3) Biofluid dynamics, (4) Heat and mass transfer in human body, (5) Modeling in biosystem, (6) Biomedical instrumentation, (7) Biosignal measurement, (8) Biosignal processing, (9) Medical imaging, (10) Artificial intelligence in medical applications, and (11) Computer applications in medical cares.

All of the above vertical technicalities are essential to clinical engineering integration disciplines. Also, the horizontal technicality or the profession of clinical engineering itself involves either "clinical engineering practices" or "medicine and hospital system engineering" or the two. With these integrating disciplines, the clinical engineering practices in hospitals can integrally fulfill versatile clinical field-supports.

Medical devices applied in hospital clinical fields depend on their functionality's. There are four typical categories essential to a clinical engineer that can be classified in the same category to train the potential clinical engineering candidates with related discipline[3]:

- (1) Biopotential related medical devices: ECG, EMG, ERG, ENG, and EEG;
- (2) Fluids, mass and heat transfer related medical devices: anesthesia machine, ventilator, oxygenator, and hemodialysis;
- (3) Medical devices in the operating room: ESU, defibrillator, and Monitors;
- (4) Energy transfer related medical devices: X-rays, fluoroscopes, angiography, computed tomography, lasers, and ultrasounds.

TECHNICAL SUPPORT TO CLINICAL SPECIALTIES

Before being a qualified CLINICAL ENGINEER, it is essential to train the candidates with competent skill and knowledge to (1) technical capabilities of applied biomedical engineering operations, (2) communication with non-technical personnel both intra- and inter-departmental, and (3) technical documentation capabilities in reading, writing, and evaluating. There are three continuing levels to be sequentially advanced, which are BMET I, BMET II, and BMET III.

The training programs of each level include different levels of professional practices and different technical objectives, which are corresponding to the clinical specialties.

INTEGRATION AND INTEGRALITY

To reduce the cost-containment of highly sophisticated devices without any deterioration of quality medical cares and to safeguard the biomedical engineering quality for clinical applications, a high-tech dependent hospital should establish two integrated systems. The one is the horizontally integrated system of clinical engineering program such as equipment control program, electrical safety program, and radiation safety program, etc. The other one is vertically direct clinical engineering supports to clinical special fields such as hemodialysis, extracorporeal membrane oxygenation, intensive care units, or surgical operating rooms. Additionally, the former one should be implemented as a hospital wide program while the later one a direct technical services or supports within clinical engineering disciplines. Consequently, a professional clinical engineer should be trained to be able to horizontally integrate the principles among medicine, engineering, and administration into a hospital wide program and vertically solve technical

problems on clinical special fields with the professional clinical engineering approaches.

MAJOR ACTIVITIES

Weekly educational courses of 2 - 3 hour duration provided by the medical doctors, professional technologists from the device companies, technical and scientific experts in biomedical engineering, senior engineers and training program instructors of the department were held from 1992. A total of 300 hours was given in last 3 years which provided continuous training and current information of medical technology for improving handling and uses of the devices. All engineers have to participate and also present their opinions and experiences during the meeting.

Technology assessment is one of the important programs of the Department. We started from procurement evaluation from 1988. The major role was to express products comparisons and further more to after services and cost-effect analysis after acquisition from 1989. We have already participated 4 stages of technology assessment from the stage of budget-planning, about 2 years before procurement, till post acquisition stage about 1 1/2 to 2 years after installation. It gives the users an excellent reference and choices of the interested devices. It has reduced the cost and expense of the hospital greatly. It also improves much the constant services of the agents of manufacturing companies in Taiwan. Of course, the results of cost-effectiveness analysis are favorable.

CONCLUSIONS

With the trained professional clinical engineering approaches, the quality of medical cares with medical devices related problems can be programmed and implemented appropriately and the technical supports to clinical fields can be performed timely and responsively.

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