

Pilot project of blood gas and electrolyte analyzer network at King Chulalongkorn Memorial Hospital

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- Objective** : *The study was introduced to implement an appropriate and effective network of blood gas and electrolyte analyzers at King Chulalongkorn Memorial Hospital (KCMH).*
- Study Design** : *The study was a descriptive study.*
- Materials and Methods** : *The study was done through the cooperation of the surgery ICU, the pediatrics ICU, and the central laboratory. The network was set by 3 blood gas and electrolyte analyzers, 1 Omni C and 2 Omni S. All instruments were connected by software named Omnilink. The study was performed from December 2004 to February 2005 and closely monitored by point-of-care (POC) coordinator from the central laboratory. The results were evaluated by evidence-base and questionnaires.*

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- Results** : *The samples of arterial blood gases and electrolytes were managed under the network and data were collected by Omnilink software. The system, software, rapidity, specimen application, auto QC, and QC under the control of the central laboratory was evaluated using the data from the software and questionnaires. We found satisfaction of the software, instrument and hardware, convenience and rapidity, system and specimen application, auto QC and QC under the control of the central laboratory, and laboratory coordinator's performance were: 3.8, 3.8, 3.5, 3.9, 3.8 and 3.7 out of 5, respectively. The confidence of the accuracy and precision of the results were 3.8.*
- Conclusion** : *The successful network system of blood gas analyzers required friendly durable instruments with automatic quality control and remote system. The specimen application and code system for both users and patients must be easy, rapid, and convenient. The training programs must cover using, maintenance, monitor, and trouble shooting. Additionally, data management system must be designed before implement. The roles of doctors, nurses, and laboratory technicians, must be clearly assigned. Any problem due to workload must also be solved. Laboratory coordinator/s and teamwork are need as well as critical ward coordinator/s and team. Closer cooperation of the involved department and wards should be set as a team or a committee that meet regularly to discuss and correct the problems together.*
- Keywords** : *Blood gas and electrolyte analyzer, Network, Point-of-care testing (POCT).*

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วัตถุประสงค์ : เพื่อทดลองวางระบบเครือข่ายเครื่องตรวจวิเคราะห์ก๊าซ และสารเกลือแร่ในเลือด ในโรงพยาบาลจุฬาลงกรณ์

รูปแบบการศึกษา : การศึกษาเชิงพรรณนา

วัสดุและวิธีการ : การศึกษานี้เกิดจากความร่วมมือของหอผู้ป่วยหนักศัลยกรรม หอผู้ป่วยหนักกุมาร และห้องปฏิบัติการกลาง ระบบเครือข่ายประกอบไปด้วยเครื่องตรวจวิเคราะห์ก๊าซและสารเกลือแร่ในเลือดจำนวน 3 เครื่อง ได้แก่เครื่อง Omni C จำนวน 1 เครื่อง และ Omni S จำนวน 2 เครื่อง เครื่องตรวจวิเคราะห์ก๊าซและสารเกลือแร่ในเลือดทั้งหมดเชื่อมต่อกันด้วยโปรแกรม Omnilink การศึกษานี้ดำเนินการระหว่างเดือนธันวาคม พ.ศ. 2547 - กุมภาพันธ์ พ.ศ. 2548 และได้รับการติดตามควบคุมอย่างใกล้ชิดโดย ผู้ประสานงานจากห้องปฏิบัติการกลาง ผลการศึกษาประเมินจากข้อมูลที่ได้จากโปรแกรมและแบบสอบถาม

ผลการศึกษา : ตัวอย่างเลือดที่ส่งมาเพื่อการค่าตรวจวิเคราะห์ก๊าซและสารเกลือแร่ในเลือดได้รับการดำเนินการโดยระบบเครือข่ายข้อมูลได้รับการบันทึกด้วยโปรแกรม Omnilink มีการประเมินโปรแกรม เครื่องมือ/อุปกรณ์ ความสะดวกรวดเร็วการใช้เครื่อง การควบคุมคุณภาพอัตโนมัติ และการควบคุมคุณภาพภายใต้การดูแลของห้องปฏิบัติการกลาง การประสานงานจากผู้ประสานงานจากห้องปฏิบัติการกลาง พบว่าผลจากข้อมูลที่ได้จากโปรแกรม และแบบสอบถาม พบว่าได้คะแนน 3.8, 3.8, 3.5, 3.9, 3.8 และ 3.7 ตามลำดับ จากคะแนนเต็ม 5 ส่วนความมั่นใจต่อความถูกต้องและแม่นยำเท่ากับ 3.8

- สรุป** : พบว่าการวางระบบให้ประสบความสำเร็จต้องการ เครื่องตรวจวิเคราะห์ ที่ทนทานใช้ง่าย มีระบบควบคุมคุณภาพอัตโนมัติที่สามารถควบคุมได้จาก ระยะไกล การใช้เครื่องรวมทั้งการป้องกันสำหรับผู้ใช้ และทะเบียนผู้ป่วย ต้องง่ายทำได้เร็ว และสะดวก การฝึกอบรมต้องครอบคลุมการใช้ การบำรุงรักษา การควบคุมติดตาม การแก้ไขปัญหา นอกจากนี้การจัดการข้อมูล ต้องได้รับการออกแบบก่อนการวางระบบ บทบาทของแพทย์ พยาบาล และบุคลากรของห้องปฏิบัติการต้องมีความชัดเจน ปัญหาจากภาระงาน ต้องได้รับการแก้ไข การทำงานของห้องปฏิบัติการต้องมีผู้ประสานงานจาก ห้องปฏิบัติการและทีมงาน และเช่นเดียวกันต้องมีผู้ประสานงานจากหอผู้ป่วยวิกฤตและทีมงาน การทำงานร่วมกันอย่างใกล้ชิดควรดำเนินการโดย ตั้งคณะทำงานที่มีการปรึกษา และแก้ไขปัญหาร่วมกัน
- คำสำคัญ** : เครื่องตรวจวิเคราะห์ก๊าซและสารเกลือแร่ในเลือด, เครื่องช่วย, การตรวจทางห้องปฏิบัติการ ณ จุดที่ดูแลผู้ป่วย

In Thailand, point-of-care testing (POCT) has been performed in critical wards, such as intensive care unit (ICU), cardiac care unit (CCU), operating room (OR), and emergency room (ER). Nowadays, it is an essential part in these critical care areas. Although the services started several years ago to support the clinicians in rapid treatment decisions, but the appropriate and effective management of quality control, standardization and harmonization, integrated informatics, instrument maintenance, POC training, and billing system are in the beginning stage.⁽¹⁾ In addition, the Joint Commission on Accreditation of Healthcare Organizations (JCAHO) has implemented a new accreditation process that included POCT in 2004. In the more than 4,000 JCAHO-accredited laboratories POCT, whether under the central laboratory's CLIA certificate or under its own, will be participating in this new inspection process.⁽²⁾ In 2006, the International Organization for Standardization (ISO) has established Point-of-care Testing (POCT)-Requirements for quality and competence as ISO 22870: 2006. This standard was prepared for POCT in hospital, clinic, and ambulatory care and was intended to be used in conjunction with ISO 15189: 2003.⁽³⁾ In Thailand, the accreditation for POCT is in processing and directed toward international practice standard.

The Central Laboratory of King Chulalongkorn Memorial Hospital (KCMH) is famous as the first laboratory in Asia that has been accredited by ISO 15189: 2003, on 30th April 2004.⁽⁴⁾ In order to implement an appropriate and effective network of POCT at KCMH the pilot study of blood gas analyzer network system were designed. Besides, to test the possibility of setting an appropriate and effective of blood gas

analyzer network, the aims of the study were to learn from a real situation and solve the problems before setting the network as well as to illustrate the practical situation and design the suitable network system for KCMH.

Materials and Methods

The study was done under the cooperation of healthcare staff of surgery ICU Sirinthorn 2, pediatrics ICU So-Ko 8, and central laboratory. The network was set by 3 blood gas analyzers, 1 Omni C and 2 Omni S. All instruments were connected by software named Omnilink⁽⁵⁾ that connected through the hospital LAN under the cooperation of the hospital computer unit. The study was performed from December 2004 to February 2005 and closely monitored by a point-of-care (POC) coordinator from the central laboratory.

Omni C⁽⁶⁾ is claimed to be able to measure 10 parameters such as PO_2 , PCO_2 , Na^+ , K^+ , Ca^{2+} , Cl^- , total hemoglobin (tHb), oxygen saturation (SO_2), hematocrit (Hct), and calculated parameters such as H^+ , $cHCO_3^-$, $ctCO_2$ (P), BE, BE_{act} , BE_{ecf} , BB, pH_{st} , $cHCO_3^-$, PAO_2 , nCa^{2+} , Qs/Qt , P50, SO_2 (c), $AaDO_2$, a/AO_2 , $avDO_2$, AG, OER, Hct (c), PAO_2^t , RI^t , pH^t , PCO_2^t , PO_2^t , H^t , $AaDO_2^t$. The parameters can be activated and deactivated temporarily by a single key stroke. It is a graphic user interface with icon guides through each operation step, and functions can be assessed and controlled via the full color screen. Low sample volume (typically <60 μ L) can be applied through a sample port system allows direct aspiration from syringes, capillaries, micro-sampler, ampoules, and result reported in 50 seconds.

Omni S⁽⁷⁾ is claimed to be able to measure more than 20 parameters such as: PO_2 , PCO_2 , pH,

Na⁺, K⁺, Ca²⁺, Cl⁻, glucose, lactate, blood urea nitrogen (BUN), O₂Hb, HHb, COHb, MethHb, tHb, SO₂, Hct, bilirubin. It could also function and provide calculated parameters as reported by Omni C.

The sample application was performed by residents who trained and evaluated for their performance. A laboratory coordinator was set from medical technologist (MT) team who worked in the central laboratory of KCMH. Calibration was done according to recommendations of the manufacturers. Internal quality control was performed twice a day, using 2 from 3 of control levels. Control number 1 and 2, then 2 and 3, then 3 and 1, etc. were serially set. Remote QC was monitored 24 hours as well as blood-gas analysis results and sample data through Omnilink software. The results of this pilot study were evaluated by evidence-base and questionnaires. One hundred questionnaires were distributed to administrators, doctors, residents, nurses, MTs, and personnel involved in this study. Thirty-three filled questionnaires were returned for evaluation.

Results

We found that 306 samples from surgery ICU Sirinthorn, 2 of them were analyzed from 2nd December 2004 to 3rd February 2005 or 64 days (average 4.8 samples per day), while 539 samples from pediatrics ICU So-Ko, 8 of them were analyzed from 22nd December 2004 to 3rd February 2005 or 44 days (average 12.2 samples per day). In addition, 905 samples were analyzed at the central laboratory from 2nd December 2004 to 3rd February 2005 or 64 days (average 14.1 samples per day). There were some problems about QC, too fast circulation of residents, and instrument function. However, all problems could be solved smoothly by cooperation of POCT team.

Thirty-three questionnaires were submitted for evaluation: 14 were filled questionnaires from the central laboratory (14 of 33 or 42.42 %), 11 from pediatrics ICU So-Ko 8 (11 of 33 or 33.33 %), and 8 from surgery ICU Sirinthorn 2 (8 of 33 or 24.24 %). From the medical personnel, the questionnaires were submitted by 14 doctors (14 of 33 or 42.42 %),

Table 1. Satisfaction score of medical personnel to POCT setting.

Topics	Medical personnel (number)				
	Doctors (14)	Nurses (4)	Lab personnel (13)	Administrative (2)	Total (33)
Software	3.9	3.7	3.5	4.0	3.8
Instrument and hardware	4.0	3.7	3.3	4.0	3.8
Convenience and rapidity	3.8	3.5	2.7	4.0	3.5
Satisfaction of system setting	4.1	3.7	3.2	4.5	3.9
Satisfaction of quality setting	3.5	3.7	3.5	4.5	3.8
Satisfaction of laboratory coordinators	3.4	3.8	2.6	5.0	3.7
Total	3.8	3.7	3.1	4.3	3.8

5 = very good, 4 = good, 3 = fair, 2 = poor, 1 = unacceptable

Table 2. Opinion of medical personnel to have password for operation the POCT.

	% of medical personnel (number)				
	Doctors (14)	Nurses (4)	Lab personnel (13)	Administrative (2)	Total (33)
Agree to use password for operation.	71.4	25.0	76.9	100	69.7
Do not want to use password for operation.	21.4	50.0	23.1	0	24.2
No opinion.	7.2	25.0	0	0	6.1

4 nurses (4 of 33 or 12.12 %), 12 MTs (12 of 33 or 36.36 %), 1 technician assistant (1 of 33 or 3.03 %), and 2 administrators (2 of 33 or 6.06 %). As for the 2 administrators, one is executive administrator of the hospital and one is administrator of the central laboratory. Satisfaction score of medical personnel to POCT setting was presented by Table 1. Table 2 demonstrated the opinion of medical personnel about password for operation the POCT. Table 3 showed the parameters that medical personnel agree by priority from top down.

Table 3. Need of parameters, priority from top to below.

● Blood Gas; pH, PO ₂ , PCO ₂
● E'lyte; Na ⁺ , Cl ⁻ , K ⁺ , Ca ²⁺
● Oxygen Saturation; SO ₂
● Hematocrit; Hct
● Co-oximetry; O ₂ Hb, HHb, COHb, Methb
● Metabolyte; Lactate, Glucose, Urea
● Bilirubin
● Total Hemoglobin; tHb

Discussion

From one hundred questionnaires we got thirty-three filled questionnaires or 33 % for evaluation. One important reason to explain this low response rate was lost of contact due to circulation of many doctors and nurses to other wards. From table 1, we found satisfaction of the software, instrument and hardware, convenience and rapidity, system and specimen application, auto QC and QC under control of the central laboratory, and laboratory coordinator's performance were 3.8, 3.8, 3.5, 3.9, 3.8 and 3.7 from 5, respectively. The confidence of the accuracy and precision of the results were 3.8. These data suggested that the total system setting scored between fair to good. Analysis by grouping of medical personnel, we found that administrative had higher scores of satisfaction, while laboratory personnel scored the lowest. The reasons of these score pattern could be explained as: the administrative could achieve management of POCT effectively and satisfied from quality control system which should be developed to assure POCT results while the laboratory personnel ignored their role in support of the POCT system since these instruments were set in wards without their involvement and

acknowledgement. In addition, the laboratory personnel felt their responsibility is only in the central laboratory. In order to build support from the central laboratory, the hospital policy must be set and communicate to all medical personnel involvement. The working team must to be established as well as role of these personnel should be clearly documented. The clinicians and nurses felt more confident to the results received from POCT that were under quality controlled from the central laboratory, since they accepted the role of laboratory personnel in quality control. Furthermore, POCT offers the opportunity to improve efficiency and therefore improve patient outcomes and quality of care.⁽⁸⁾ However, POCT is processed under medical care team and some roles of involved personnel must be adjusted. Examples of these, such as clinicians or nurses should take role of sample analysis, nurses should take responsibility in maintenance the instruments, etc. Additionally, any problem due to workload must also be solved. Laboratory coordinator and team are need as well as critical ward coordinators and team. The close cooperation of the involved department and wards should be set as a team or a committee that meet regularly to discuss and correct the problem together which was not different from a previous study.⁽⁹⁾

Regarding the use of password to access the system (Table 2), this is important for system development and training of users. Although nurses were unhappy to use password to access the system because of their fear of mistake and blame, but in principle it is agreed that the use of password was needed. The team should make agreement of continuous quality improvement more than blaming

anyone for their mistake. Training should be set according to their periodical needs. The training programs must cover system utility, maintenance, monitoring and trouble shooting. All risk and mistakes must be analyzed and corrected, and the protection system should be established. In addition, the passwords for both the users and patients should be easily keyed to the system. Furthermore, parameters should be selected according the need of the patients and requirements of the clinicians (Table 3). Additionally, blood gas and electrolyte tests are the most important group of tests and they should always be made available as the priority tests in critical areas.⁽¹⁰⁾ In detail, our parameter priority setting is not different from others.⁽¹¹⁾ The model of instruments is important and should be agreed upon by POCT team, since the successful network system of blood-gas analyzers required friendly durable instruments with automatic quality control and remote system. In summary, in order to be successful in building a POCT team, all medical personnel must focus on the results of patient outcomes and adjust their roles appropriately.

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References

1. Charuruks N, Prasopsanti K, Noppakun N. Goals for point-of-care testing in Thailand: a need assessment study from King Chulalongkorn Memorial Hospital. *Point of Care* 2003; 2(4): 265-8
2. Darcy T. The new and improved Joint Commission laboratory accreditation process: welcome tracer methodology. *Point of Care* 2004; 3(3): 96-8
3. Technical Committee ISO/TC 212. Clinical laboratory testing and in vitro diagnostic test system. ISO 22870. Point-of-care Testing (POCT)-Requirements for quality and competence. Feb 1, 2006
4. Technical Committee ISO/TC 212, Clinical laboratory testing and in vitro diagnostic test system. ISO 15189, Medical laboratories – particular requirements for quality and competence. Feb 15, 2003
5. Roche Diagnostics GmbH. Omnilink: Maximise your "Careholder Value". Roche Near Patient Testing D-68298 Mannheim, Germany. Available from: URL://http:www. Roche-diagnostics.com/npt
6. Roche Diagnostics GmbH. Roche Omni C: Redefining the basics in critical care testing. Roche Near Patient Testing D-68298 Mannheim, Germany. Available from: URL: <http://www. Roche-diagnostics.com/npt>
7. Roche Diagnostics GmbH. Roche Omni S: Going far beyond the basics in critical care testing. Roche Near Patient Testing D-68298 Mannheim, Germany. Available from: URL: <http://www. Roche-diagnostics.com/npt>
8. Bourke SE, Kirk JD, Kost GJ. Point-of-care testing in emergency medicine. In: Kost GJ, ed. *Principles & Practice of Point-of-Care Testing*. Philadelphia: Lippincott Williams & Wilkins, 2002: 99-118
9. Ballard J, Salyer J, Pedersen D, et al. Implementing a point-of-care blood gas-testing system in NICU. *Respir Care* 1998;43(10):859
10. Holloway PA. Point-of-care testing in intensive care. In: Kost GJ, ed. *Principles & Practice of Point-of-Care Testing*. Philadelphia: Lippincott Williams & Wilkins, 2002: 133-56
11. Castro HJ, Oropello JM, Halpern N. Point-of-care testing in the intensive care unit. The intensive care physician's perspective. *Am J Clin Pathol* 1995 Oct;104 (Suppl 1):S95-9