KSCCM Annual Congress and Acute Critical Care Conference 2019
Drug Prescription in the ICU and the Role of Pharmacists

The Role of Critical Care Pharmacists - Past, Present, and Future

2019.04.26.

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In the era of the 4th industrial revolution

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- Multidisciplinary approach to the management of critically ill patients may be an important factor in the quality of care provided in the ICU.

- The presence of a team of health professionals from various disciplines, working in concert, may improve efficiency, outcome, and the cost of care for patients hospitalized in the ICU

Critical care delivery in the intensive care unit: Defining clinical roles and the best practice model

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Ref. Crit Care Med. 2001;29(10):2007-2019

Critical Care Pharmacist Activities

- **Multidisciplinary Critical Care**

1. Comprehensive critical care units should be directed by an intensivist, as defined by the SCCM, in collaboration with a defined nursing director.

2. Patient management should be directed by an attending physician who is credentialed by the hospital medical staff to provide care to critically ill patients.

3. Critical care attending physicians should be available to provide bedside care within 30 mins, and in-hospital ICU physician coverage must have sufficient expertise to provide emergency management including, but not limited to, airway emergencies.

4. All nursing care should be provided by critical care trained nurses.

5. Respiratory therapists with a working knowledge of the principles of respiratory failure management should be dedicated to the ICU 24 hrs per day.

6. Pharmacy services should be available to provide ICU-dedicated pharmaceutical care and consultation.

Ref. Crit Care Med. 2001;29(10):2007-2019

Critical Care Pharmacist

- **Position Paper on Critical Care Pharmacy Services**
- To identify and describe the scope of practice
- To define the level of clinical practice and specialized skills
- To recommend fundamental, desirable, & optimal pharmacy services

Position paper on critical care pharmacy services

Maria I. Rudis, PharmD, ABAT, BCPS; Katherine M. Brandl, PharmD, BCPS, for the Society of Critical Care Medicine and American College of Clinical Pharmacy Task Force on Critical Care Pharmacy Services

Objective: The goal of the Task Force on Critical Care Pharmacy Services was to identify and describe the scope of practice that characterizes the critical care pharmacist and critical care pharmacy services. Specifically, the aims were to define the level of clinical practice and specialized skills characterizing the critical care pharmacist as clinician, educator, researcher, and manager; and to recommend fundamental, desirable, and optimal pharmacy services and personnel requirements for the provision of pharmaceutical care to critically ill patients. Hospitals having comprehensive resources as well as those with more limited resources were considered.

Data Sources: Consensus opinion of critical care pharmacists from institutions of various sizes providing critical care services within several types of pharmacy practice models was obtained, including community-based and academic practice settings. Existing guidelines and literature describing pharmacy practice and medication use processes were reviewed and adapted for the critical care setting.

Conclusions: By combining the strengths and expertise of critical care pharmacy specialists with existing supporting literature, these recommendations define the level of clinical practice and specialized skills that characterize the critical care pharmacist as clinician, educator, researcher, and manager. This Position Paper recommends fundamental, desirable, and optimal pharmacy services as well as personnel requirements for the provision of pharmaceutical care to critically ill patients. (Crit Care Med 2000; 28:3746–3750)

Key Words: guidelines; posture paper critical care; pharmacy services; clinical pharmacy; intensive care; critical care services

Ref. Crit Care Med. 2000;28:3746-3750

Critical Care Pharmacist Activities

- **Fundamental Activities**

- A pharmacist dedicated to critical care services whose activities are vital to the safe provision of pharmaceutical care

● Evaluates patient drug regimens based on the pharmaceutical care model and assesses their efficacy

● Provides nutritional care

● Prevents and documents ADEs and medication errors

● Provides written communication of recommendations

● Monitors pharmacokinetics

● Provides drug information

● Educates other healthcare professionals

● Participates in reports for accrediting agencies, institutional committees, and programs

Ref. intensive Care Med. 2003;29:691-698

Critical Care Pharmacist Activities

- **Desirable Activities**

- In addition to fundamental activities,

  includes more specialized critical care pharmaco-therapeutic services

- Participates in patient care rounds
- Maintains knowledge of primary literature
- Reviews medication history
- Educates through didactic/experiential teaching
- Aids in preparing protocols and critical care pathways
- Contributes to research and medical writing

Ref. intensive Care Med. 2003;29:691-698

Critical Care Pharmacist Activities

- **Optimal Activities**

- In addition to fundamental and desirable activities, includes an integrated, specialized, and dedicated model of critical care which aims to optimize pharmaco-therapeutic outcomes through the highest level of teaching, research and pharmacotherapy practices

- Facilitates patient/family discussions about treatment

- Provides accredited educational sessions

- Reports results of his/her independently initiated/collaborated clinical, pharmacoeconomic, and outcomes research to the medical community through lectures and publications

- Develops post-doctoral training programs

Ref. intensive Care Med. 2003;29:691-698

Critical Care Pharmacist Service in Korea

- **History of Critical Care Pharmacy in Korea**

1994	1996.03	2003.06	2006.08	2008.11	2010.08
신생아, 소아심장외과 중환자실	신생아 중환자실	신생아 중환자실	신생아 중환자실	외과계 중환자실	외과계 중환자실
삼성서울병원	서울아산병원	분당서울대학교병원	서울대학교병원	아주대학교병원	세브란스병원

2011.03	2011.05	2011	2012.10	2014.10	2014.10
내과계·외과계 중환자실	내과계 중환자실	내과계 중환자실	내과계 중환자실	내과계·외과계 중환자실	내과계 중환자실
중앙대학교병원	전북대학교병원	서울성모병원	충남대학교병원	고대구로병원	서울특별시 보라매병원

Ref. Current Status of Pharmaceutical Care in Intensive Care Units in Korea

(조사기간: 2018년 7월~2018년 9월)

Critical Care Pharmacist Service in Korea

- **중환자실 적정성 평가 도입 (2014.04)**

- 지표: 다직종 회진 일수 비율
- 정의: 중환자 전담전문의에 의한
  다직종 회진이 이루어지고 있는 일수 비율

* 다직종 회진:

① 회진팀은 **3직종 이상**으로 구성:

전담전문의 및 중환자실 **간호사** 외 **1인(약사, 영양사, 물리치료사)** 이상

② **주 2회 이상 회진** 시행(주말 및 공휴일 제외):

전담전문의가 주도되어 회진팀이 함께 회진하여야 하며,

전담전문의가 있는 Unit은 회진을 모두 시행하여야 함 (관상동맥중환자실 제외)

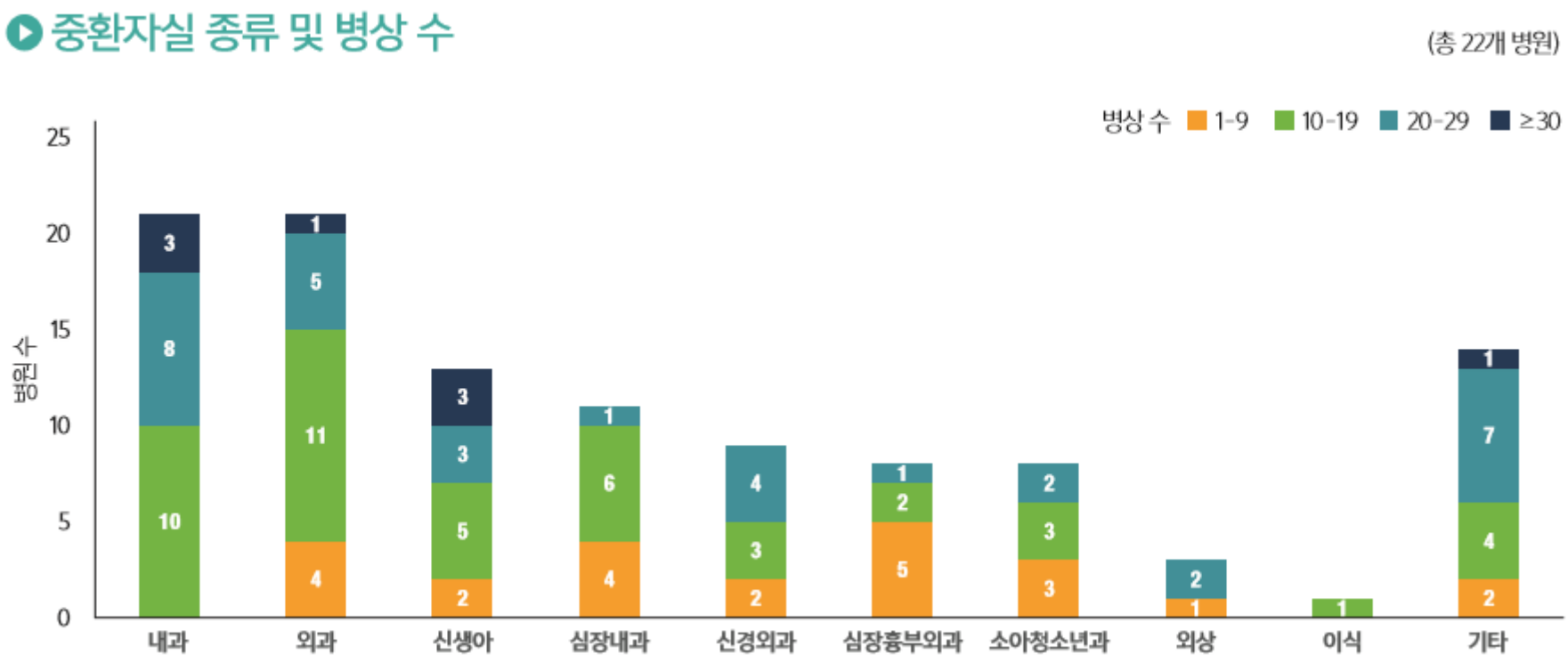
③ 회진 일수: Unit이 여러개일 경우, 각 Unit의 회진 일수 평균

Ref. Current Status of Pharmaceutical Care in Intensive Care Units in Korea

(조사기간: 2018년 7월~2018년 9월)

Critical Care Pharmacist Service in Korea

- **Current Status of Critical Care Pharmacy in Korea**



Ref. Current Status of Pharmaceutical Care in Intensive Care Units in Korea

(조사기간: 2018년 7월~2018년 9월)

Critical Care Pharmacist Service in Korea

- **Cause and types of intervention by pharmacists (MICU)**

Table 2. Causes for intervention by pharmacists

	Number (%)
Inappropriate dosage and administration	431 (34.5)
Parenteral/enteral nutrition	229 (18.3)
Adverse drug reaction	148 (11.9)
No drug prescription	89 (7.1)
Inappropriate drug selection	73 (5.8)
Request for drug information	68 (5.4)
Drug interactions	46 (3.7)
Drug duplication	24 (1.9)
Inappropriate duration	25 (2.0)
Unnecessary drug usage	22 (1.8)
Inappropriate laboratory test	21 (1.7)
Inappropriate insurance criteria	2 (0.2)
Other	70 (5.6)

Table 4.Types of pharm
pharmacists*

Adjustment of dosage and ad
Adjustment of parenteral/ente
Provision of drug information
Pharmacokinetics advice
Suggestion to discontinue dru
Suggestion of drug initiation
Recommendation for alternati
Recommendation or modifica
Change in insurance criteria
Other

*It is possible to select more th

중재 유형 (건)	1202
용법/용량	589 (49.0)
상호작용	58 (4.8)
질병금기	16 (1.3)
약제추천	250 (20.8)
누락	32 (2.7)
불필요처방	124 (10.3)
TDM	58 (4.8)
중복	44 (3.7)
부작용	13 (1.1)
제형	5 (0.4)
기타	13 (1.1)

Ref. Korean J Crit Care Med 2015;30(2):82-88

J Kor Soc Health-Syst Pharm. 2018;35(3):319-330

Critical Care Pharmacist Service in Korea

- **Cause and types of intervention by pharmacists (SICU)**

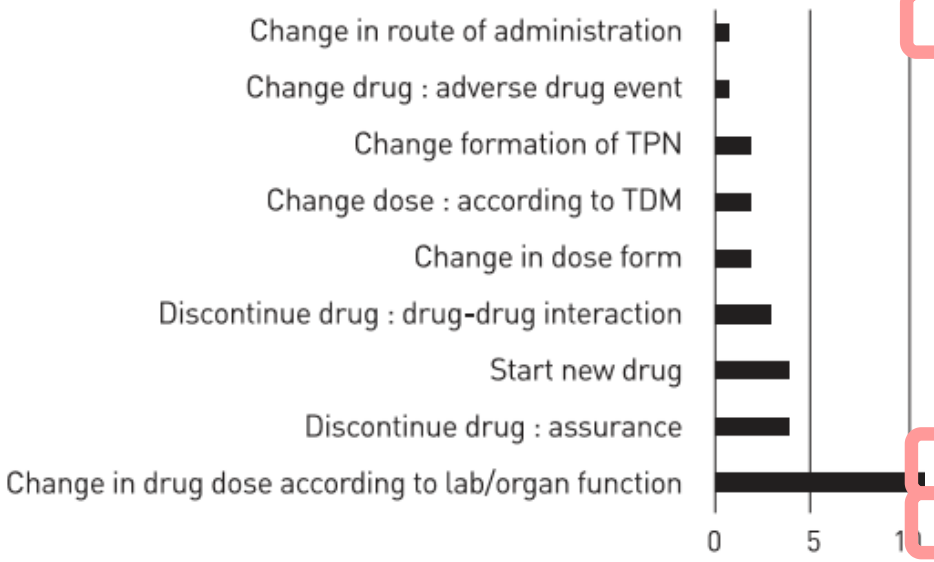


Fig. 2 Drug related interventi

The 38 (67%) of drug-related interventions were to adjust dosage re

	전담약사 업무 시행 후 중재 내용 건 (%)
용량/용법 오류	206 (41.2)
중복처방	20 (4.0)
제형 오류	7 (1.4)
약물 상호작용 가능성	6 (1.2)
적응증에 해당하지 않음	6 (1.2)
투여금기	1 (0.2)
Mix 수액	3 (0.6)
정맥영양지원	163 (32.6)
약물 추천 및 치료계획 공유	53 (10.6)
약물 이상반응 가능성	16 (3.2)
임상약동학 자문	14 (2.8)
Lab data 부족	3 (0.6)
보험 삭감 가능성	2 (0.4)
합계	500 (100)

Ref. J Kor Soc Health-Syst Pharm. 2014;31(4):908-918

J Kor Soc Health-Syst Pharm. 2017;34(4):401-409

Critical Care Pharmacist Service in Korea

- **Common Drug requiring pharmacist's intervention (MICU)**

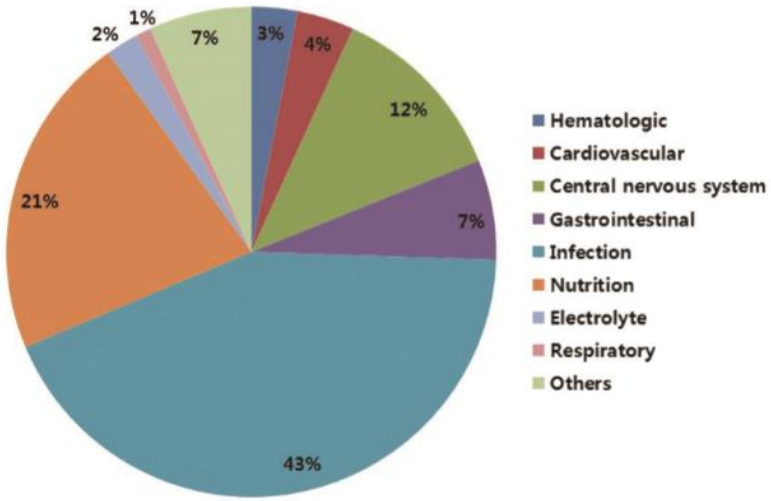


Fig. 1. Drug classification of pharmacist's intervention case.

Pantop
Ganci
Piperacillin/tazob
Flucor
Remife
Mida
Sulfamethoxazole/trimeth
Merop
Colistim
Vanco

Fig. 2. Commor
tion.

중재 약물군 (건)	1144
Antihistamine drugs	4 (0.3)
Anti-infective agents	530 (46.3)
Autonomic drugs	2 (0.2)
Cardiovascular drugs	12 (1.0)
Central nervous system agents	20 (1.7)
Anesthetics	15 (1.3)
Anesthetics 외	5 (0.4)
Electrolytics	19 (1.7)
Respiratory tract agents	1 (0.1)
Gastrointestinal drugs	133 (11.6)
Hormones and synthetic substitutes	10 (0.9)
Immunosupressive agents	6 (0.5)
Vitamins	18 (1.6)
기타	389 (34.0)
TPN	364 (31.8)
TPN 외	25 (2.2)

Ref. Korean J Crit Care Med 2015;30(2):82-88

J Kor Soc Health-Syst Pharm. 2018;35(3):319-330

Critical Care Pharmacist Service in Korea

- **Common Drug requiring pharmacist's intervention (SICU)**

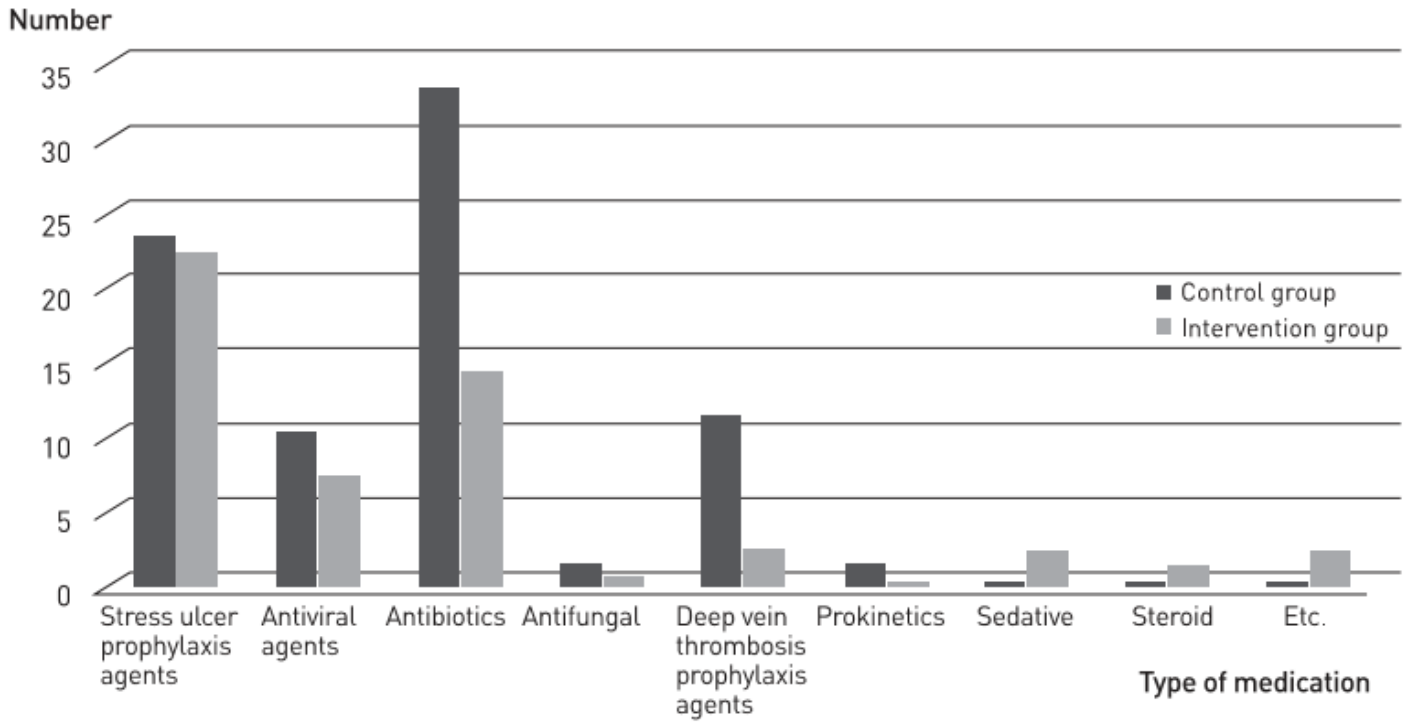


Fig. 1 The type of inappropriate prescribing medication

In the control group, the majority of inappropriate prescribing was overdose of antibiotics (41.8%). In the intervention group, the majority of inappropriate prescribing was overdose of stress ulcer prophylaxis agents (44.9%)

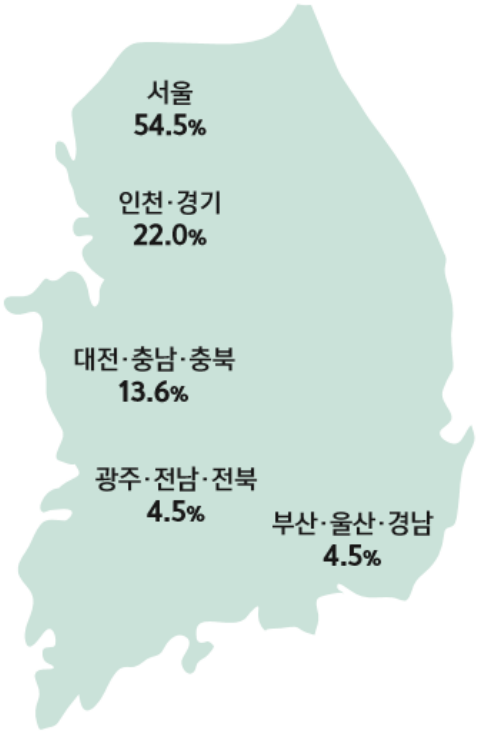
Ref. J Kor Soc Health-Syst Pharm. 2014;31(4):908-918

Critical Care Pharmacist Service in Korea

- **Current Status of Critical Care Pharmacy in Korea**

근무 병원 소재지

(총 22개 병원)



근무 병원 종류

상급종합병원
72.7%
(16개 병원)

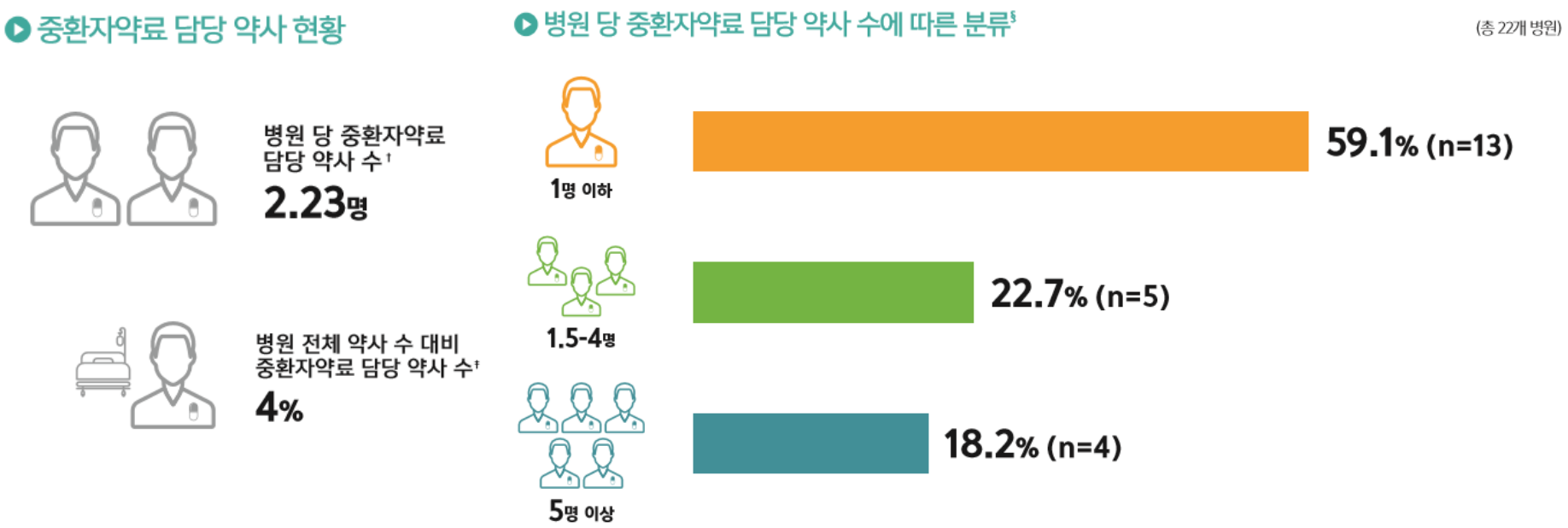
종합병원
27.3%
(6개 병원)

Ref. Current Status of Pharmaceutical Care in Intensive Care Units in Korea

(조사기간: 2018년 7월~2018년 9월)

Critical Care Pharmacist Service in Korea

- **Current Status of Critical Care Pharmacy in Korea**



Ref. Current Status of Pharmaceutical Care in Intensive Care Units in Korea

(조사기간: 2018년 7월~2018년 9월)

Critical Care Pharmacist Service in Korea

- **Current Status of Critical Care Pharmacy in Korea**

운영 병원	업무 범위
고려대학교 구로병원	처방검토 및 중재, 임상 자문업무, 조제, 감사, 약물정보 제공, 교육, 연구, 프로토콜 정비
대전성모병원	
분당서울대학교병원	
삼성서울병원	
서울대학교병원	
서울성모병원	
서울아산병원	
서울특별시 보라매병원	
세브란스병원	
아주대학교병원	
전북대학교병원	
중앙대학교병원	
충남대학교병원	처방검토 및 중재, 임상 자문업무, 약물정보 제공, 교육, 연구, 프로토콜 정비

분야	내용	
임상	• 약물요법에 대한 평가 • 약물 부작용 예방 보고 및 감시 • 약물 상호작용 확인 • 투약력 검토 • 적절한 영양요법 제공	• 약물 효과 모니터링 • 약동학적 감시 • 환자 개인별 약물요법 중재 • 정맥투여 배합금기 및 안정성 정보 제공 • 정기적으로 회진 참여
교육	• 중환자 의료팀에게 약물요법과 약물관련 방침에 대한 교육 • 의료진을 대상으로 정기적인 교육 제공 • 중환자약료 관련 강의 수행 • 중환자실 담당약사 훈련과정 운영 • 약학대학 학생 실습 교육	
학술	• 중환자약료 관련 연구에 참여	• 중환자 약물 프로토콜 개발
행정	• 적절한 약물 사용을 통한 약제비 절감 방법 모색 • 중환자실 인증 대비	• 약물 치료를 향상시키기 위한 질 향상 프로그램 참여

Ref. Current Status of Pharmaceutical Care in Intensive Care Units in Korea (조사기간: 2018년 7월~2018년 9월)

Impact of Critical Care Pharmacists

- **ICU pharmacist interventions and clinical outcomes**

Reference	Type of ICU	Number of interventions	Pharmacist interventions	Clinical outcomes
3	Medical-surgical	N/A	Installing a pharmacy computer system and suggesting antibiotic therapies	Reduced rates of ventilator-associated pneumonia from 40 VAPs/1,000 ventilator days to 12 VAPs/1,000 ventilator days
7	Medical- surgical	12 out of 50 patients	Recommend sedatives	Similar median mechanical ventilation weaning time when compared to control
23	Surgical, medical or mixed	N/A	Routine activities of a clinical pharmacist	3.3% reduction of medication errors compared to other studies
24	Medical	N/A	Monitoring train of four and drug dosages	85% greater chance of receiving neuromuscular function recovery and spontaneous ventilation
28	N/A	N/A	Continuous infusion medications were concentrated in smaller volumes, medications were added to parenteral nutrition when possible	Approximately 5 l decrease in cumulative balances for patients that received pharmacist intervention compared to those who did not
35	Medical	44 infusion rates were changed	Therapeutic drug monitoring	25% reduction in inappropriate concentrations
37, 61	Medical	398	Correcting clarifying orders, providing drug information, suggesting alternative therapies, identifying drug interactions	66% reduction of ADEs

Ref. intensive Care Med. 2003;29:691-698

Impact of Critical Care Pharmacists

- **Articles (2015-2016) evaluating critical care pharmacist practices**

Study	Clinical context	Patient population and country	Pharmacist interventions	Outcomes evaluated	Comments
Tripathi[15]	Infectious disease – central line infections	Pediatric ICU in a hospital in the United Sates	Drug dosing, drug interaction management, monitoring route selection, drug selection 80% of interventions were accepted.	Central line infections decreased as a result of less central line placement, which was proposed to be from a decrease in the use of IV antibiotics. 1.6% of interventions prevented life-threatening situations.	Pharmacist interventions increased over time.
Beardsley[25]	Infectious disease – sepsis	Tertiary academic medical hospital in United States	Initiated code sepsis alert, assessed patient information, contributed to and initiated antibiotic selection	Reduced time to antibiotic delivery, time to antibiotic administration, and mortality	Interprofessional initiative
Michalets[14]	Preventable ADEs	Neurotrauma ICU in a community health system in United States	Participated in patient care rounds and developed of patient care plans Clinical pharmacist practitioner: drug ordering and monitoring following physician diagnosis	24% further reduction in preventable ADEs Relative risk of ADE severity was reduced.	These are expanded critical care pharmacist services with an increase in clinical pharmacist practitioners from 1 to 3.

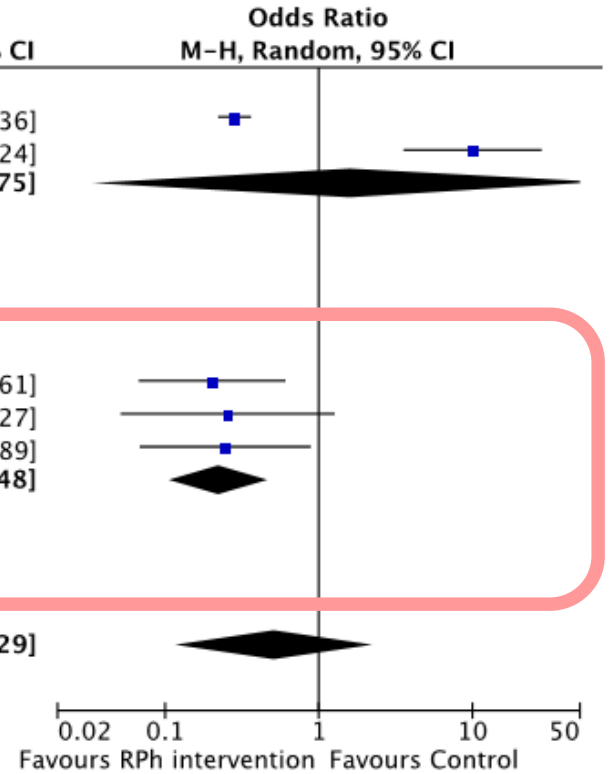
Ref. Hosp Pharm. 2016;51(7):507-513

Impact of Critical Care Pharmacists

- **MEs and Preventable ADEs**

  between ICU patients with pharmacist interventions or control

Study or Subgroup	RPh intervention Events	RPh intervention Total	Control Events	Control Total	Weight	Odds Ratio M-H, Random, 95% CI
1.8.1 Medication errors						
Klopotowska 2010	369	5901	96	504	22.4%	0.28 [0.22, 0.36]
Lee 2007	38	692	4	694	20.3%	10.02 [3.56, 28.24]
Subtotal (95% CI)		**6593**		**1198**	**42.8%**	**1.64 [0.03, 77.75]**
Total events	407		100			
Heterogeneity: Tau^2 = 7.62; Chi^2 = 52.64, df = 1 (P < .00001); I^2 = 98%						
Test for overall effect: Z = 0.25 (P = .80)						
1.8.2 Preventable adverse drug events						
Kaushal 2008	5	835	9	311	20.1%	0.20 [0.07, 0.61]
Klopotowska 2010	6	5901	2	504	17.8%	0.26 [0.05, 1.27]
Leape 1999	3	861	11	787	19.3%	0.25 [0.07, 0.89]
Subtotal (95% CI)		**7597**		**1602**	**57.2%**	**0.23 [0.11, 0.48]**
Total events	14		22			
Heterogeneity: Tau^2 = 0.00; Chi^2 = 0.08, df = 2 (P = .96); I^2 = 0%						
Test for overall effect: Z = 3.92 (P < .0001)						
Total (95% CI)		**14190**		**2800**	**100.0%**	**0.52 [0.12, 2.29]**
Total events	421		122			
Heterogeneity: Tau^2 = 2.52; Chi^2 = 52.58, df = 4 (P < .00001); I^2 = 92%						
Test for overall effect: Z = 0.86 (P = .39)						
Test for subgroup differences: Chi^2 = 0.97, df = 1 (P = .33), I^2 = 0%						



Ref. Journal of Critical Care. 2015;30:1101-1106

Critical Care Pharmacotherapy research

- **Antibiotics**

Anaesth Intensive Care 2011; 39: 1030-1037

Optimal dose of vancomycin for treating methicillin-resistant *Staphylococcus aureus* pneumonia in critically ill patients

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Department of Pulmonary and Critical Care Medicine, Asan Medical Center, Seoul, Korea

SUMMARY

A prospective cohort study was performed to determine the optimal dose of vancomycin to maintain a serum trough concentration of at least 15 to 20 mg/l and to assess the efficacy of this target vancomycin concentration in the treatment of methicillin-resistant Staphylococcus aureus pneumonia. Vancomycin pharmacokinetic parameters were estimated using a CAPSIL software program from serum concentrations of 141 patients with pneumonia treated with vancomycin, regardless of methicillin-resistant Staphylococcus aureus status, at a 28-bed medical intensive care unit. Vancomycin trough concentrations and other pharmacokinetic parameters were compared between five groups of patients differing in their renal function: 1) creatinine clearance ≥60 ml/minute, 2) creatinine clearance 30 to 60 ml/minute, 3) creatinine clearance <30 ml/minute, 4) on intermittent haemodialysis, and 5) on continuous renal replacement therapy. More than 70% of patients failed to reach the recommended therapeutic serum trough concentrations: a higher dose of v at 15 to 20 mg/l, particularly in critically ill pati on intermittent haemodialysis. Among patients significant differences were observed in the treatme unit mortality rate between patients with vancomyc

Key Words: vancomycin, methicillin-resistant *Staphyl*

KJCCM
Korean J Crit Care Med
2016 August 31(3):208-220 / http://dx.doi.org/10.4266/kjccm.2016.00129
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■ Original Article ■

Clinical Effectiveness and Nephrotoxicity of Aerosolized Colistin Treatment in Multidrug-Resistant Gram-Negative Pneumonia

Seung Yong Park, M.D., Ph.D.[1*], Mi Seon Park, B.S.[2*], Chi Ryang Chung, M.D.[3], Ju Sin Kim, Ph.D.[2], Seoung Ju Park, M.D., Ph.D.[1], and Heung Bum Lee, M.D., Ph.D.[1]

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Background: Colistin (polymyxin E) is active against multidrug-resistant Gram-negative bacteria (MDR-GNB). However, the effectiveness of inhaled colistin is unclear. This study was designed to assess the effectiveness and safety of aerosolized colistin for the treatment of ventilator-associated pneumonia (VAP) caused by MDR-GNB.
Methods: In this retrospective longitudinal study, we evaluated the medical records of 63 patients who received aerosolized colistin treatment for VAP caused by MDR-GNB in the medical intensive care unit (MICU) from February 2012 to March 2014.
Results: A total of 25 patients with VAP caused by MDR-GNB were included in this study. The negative conversion rate was 84.6% after 4%, AKI group). The average length of MICU stay and colistin treat- d administration period, were not significantly different between p = 0.07). Multivariate analysis showed that a body mass index less] = 21.95, 95% confidence interval [CI] 1.59-302.23; p = 0.02). Nota- re than two nephrotoxic drugs combined with aerosolized colistin 3.10, 95% CI 1.40-161.76; p = 0.04).
appears to be a relatively safe and effective option for the treat- concomitant use of nephrotoxic drugs with aerosolized colistin will t of AKI.

a, ventilator-associated.

Kim *et al. Critical Care* 2012, **16**:R28
http://ccforum.com/content/16/1/R28

CRITICAL CARE

RESEARCH Open Access

Early use of imipenem/cilastatin and vancomycin followed by de-escalation versus conventional antimicrobials without de-escalation for patients with hospital-acquired pneumonia in a medical ICU: a randomized clinical trial

Jong Wook Kim[1†], Joowon Chung[2†], Sang-Ho Choi[3], Hang Jea Jang[4], Sang-Bum Hong[5], Chae-Man Lim[5] and Younsuck Koh[5*]

Critical Care Pharmacotherapy research

- **Drug used in Pain, Agitation, and delirium**

Dose Adjustment for Remifentanil with Regards to the Opioid-Sparing Effect of Dexmedetomidine in Critically Ill Patients

Soo Jung Han, Hyung-Sook Kim, Jeong Hwa Lee, Eunsook Lee, Yeon Joo Lee[a] and Young-Jae Cho[a,†]

Department of Pharmacy, Seoul National University Bundang Hospital

Division of Pulmonary and Critical Care Medicine, Department of International Medicine, Seoul National Universi

82, Gumi-ro 173 Beon-gil, Bundan

Effect of Pharmacist's Intervention and Management of Pain and Sedation Protocol on Clinical Outcomes in Medical ICU

Jin Yeong Ko[a], Hyo Jung Park[a], Yong Won In[a], Young Mee Lee[a], Jeong Mee Kim[a] and Seok Yong Lee[b,†]

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School of Pharmacy, Sungkyunkwan University, 2066, Seobu-ro, Jangan-gu, Suwon, Gyeonggi-do, 16419, Republic of Korea[b]

Ref. J Kor Sco Health-Syst Pharm. 2014;31(4):898-907.

J Kor Sco Health-Syst Pharm. 2018;35(3):268-280.

Critical Care Pharmacotherapy research

- **PK alteration in critically ill patients – CVVHDF, ECMO**

Clin Nephrol. 2017 Sep;88(9):148-155. doi: 10.5414/CN109216.

Predicting augmented renal clearance using estimated glomerular filtration rate in critically-ill children.

Lee B, Kim J, Park JD, Kang HM, Cho YS, Kim KS.

Abstract
AIMS: Measured glomerular filtration rate (mGFR) is often used to identify a
estimated GFR (eGFR) is obtained more quickly and inexpensively. We aim
the correlation between the eGFR and vancomycin trough level (VTL).

Analysis of Vancomycin Plasma Concentrations Following Initial Dosing in Critically Ill Patients

Yujin Lim[1], Kayoung Park, Sujeong Jeon, Hyungwook Namgung, Eunsook Lee, Kyoungho Song and Sangheon Park

Department of Pharmacy, Seoul National University Bundang Hospital,
Department of Internal Medicine
Department of Anesthesiology and Pain Medicine

RESEARCH ARTICLE

Factors affecting serum concentration of vancomycin in critically ill oliguric pediatric patients receiving continuous venovenous hemodiafiltration

Bongjin Lee[1,2], Soo Jung Kim[3], June Dong Park[1]*, Jiun Park[3], Hoi Jung[3], Yu Hyeon Choi[1], Hee Gyung Kang[1], Il Soo Ha[1], Hae Il

1 Department of Pediatrics, Seoul National University College of Medicine, Se
2 Department of Pediatrics, Chungnam National University Hospital, Daejeon,
3 Department of Pharmacy, Seoul National University Hospital, Seoul, Republ

These authors contributed equally to this work.
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Insufficient Serum Levels of Antituberculosis Agents During Venovenous Extracorporeal Membrane Oxygenation Therapy for Acute Respiratory Distress Syndrome in a Patient with Miliary Tuberculosis

Hyung-Sook Kim,* Eun Sook Lee,* and Young-Jae Cho†

Ref. J Kor Soc Health-Syst Pharm. 2014;31(4):888-897 , PLoS One. 2018;13(6):e0199158

J Kor Sco Health-Syst Pharm. 2014;31(4):898-907.

Critical Care Pharmacotherapy research

- **Drug Interaction or Adverse Drug Reaction**

Evaluation of Drug–Drug Interaction in Pediatric Intensive Care Unit

Ji Na Kim, Hyo Jung Park, Su Jin Park, Yong Won In and Young Mee Lee†

Department of Pharmaceutical Services, S

81, Irwon-ro, Gangnam-gu, Seoul,

A Methodological Approach for Detecting Adverse Drug Reactions in the Surgical Intensive Care Unit

Jina Shin[a], Su-Hyun Ryu[a], Eunyoung Sa[a], Eun Ji Lee[a], Sung Yun Suh[a], Yoon Sook Cho[a], Hyeon-Joo Hahn[a], Jin Lee[b], Hyeryeon Son[b], Dong-Yoon Kang[b] and Hye-Ryun Kang[b,c,†]

l University Hospital[a]

ational University Hospital[b]

ional University Hospital[c]

0, Republic of Korea

International Journal of Clinical Pharmacy (2018) 40:1328–1334
https://doi.org/10.1007/s11096-018-0634-8

RESEARCH ARTICLE

CrossMark

Evaluation of risk factors for vancomycin-induced nephrotoxicity

So Jin Park[1] · Na Ri Lim[1] · Hyo Jung Park[1] · Jae Wook Yang[1,2] · Min-Ji Kim[1,3] · Kyunga Kim[1,3] · Yong Won In[1] · Young Mee Lee[1]

Received: 2 April 2017 / Accepted: 4 April 2018 / Published online: 9 May 2018

Ref. J Kor Soc Health-Syst Pharm. 2016;33(2):122-129

J Kor Soc Health-Syst Pharm. 2017;34(4):422-432

Critical Care Pharmacotherapy research

- **Nutrition**

Original Communication

Effect of High vs Standard Early Parenteral Amino Acid Supplementation on the Growth Outcomes in Very Low Birth Weight Infants

Sami Yang, RPh, BCNSP[1]; Byong Sop Lee, MD, PhD[1]; Hye-Won Park, MD[2]; Yong-Sung Choi, MD[1]; Seong-Hun Jeong, MD[1]; Ji-Hee Kim, MD[1]; Ellen Ai-Rhan Kim, MD, PhD[1]; and Ki-Soo Kim, MD, PhD[1]

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Original Article

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pISSN 2289-0203 · eISSN 2383-7101
https://doi.org/10.15747/jcn.2017.9.1.21

JCN Journal of Clinical Nutrition

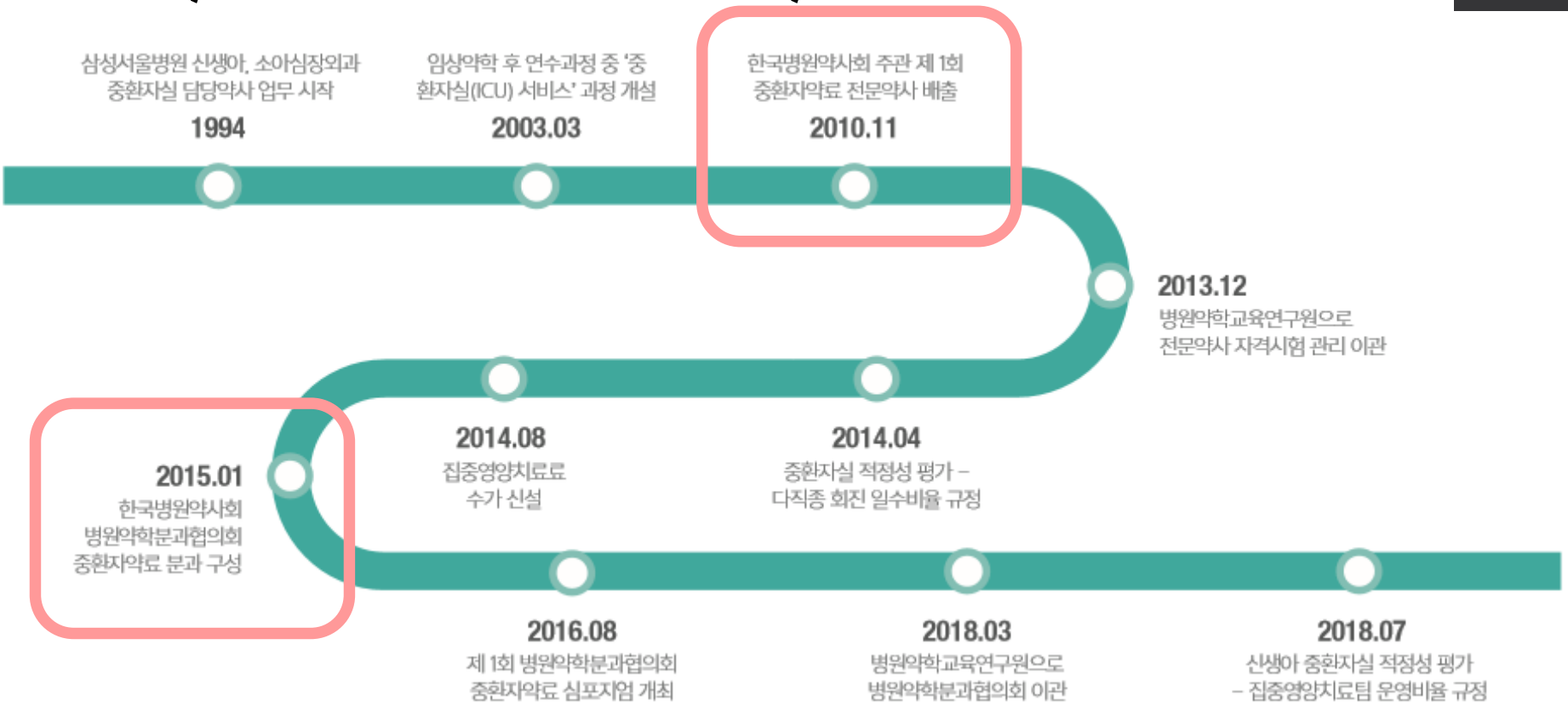
Influence of Fish Oil-Containing Lipid Emulsions on Parenteral Nutrition-Associated Liver Disease in Neonates

Jeong-A Park[1], Ji-Eun Park[1,2], Min-Jae Jeong[1,2], Jae-Song Kim[1], Eun-Sun Son[1], Ho-Seon Eun[2,3]

[1]Department of Pharmacy, Severance Hospital, [2]Pediatric Nutrition Support Team, Severance Hospital, [3]Department of Pediatrics, Yonsei University College of Medicine, Seoul, Korea

Critical Care Pharmacist Service in Korea

- **History of Critical Care Pharmacy in Korea**



Ref. Current Status of Pharmaceutical Care in Intensive Care Units in Korea

(조사기간: 2018년 7월~2018년 9월)

Critical Care Pharmacist Service in Korea

- **Current Status of Critical Care Pharmacy in Korea**

- The Critical Care Pharmacy Committee (중환자약료분과회) 활동

(병원약학교육연구원 > 병원약학분과협의회 > 중환자약료분과회)

1. 교육: 심화교육(온라인) 및 현장교육(심포지엄) 운영

2. 전문가 네트워크

3. 연구 및 학술활동

* 국내 중환자약료 현황 보고서 발간

* 중환자약료에 대한 의사-약사 업무 중요도 및 만족도 평가 연구 중

Ref. Current Status of Pharmaceutical Care in Intensive Care Units in Korea

(조사기간: 2018년 7월~2018년 9월)

Critical Care Pharmacist Service in Korea

- **Current Status of Critical Care Pharmacy in Korea**

- The Pharmacists certified in critical care pharmacotherapy

(중환자약료 전문약사) 치료성과 및 환자의 건강개선에 기여하기위해

중환자약료에 통달하고

약물요법에 보다 전문적인 자질과 능력을 갖춘 임상약사

* 중환자약료 전문약사 역량: 중환자에서 약동학적 변화의 이해, Shock과 치료에 대한 이해, 진통/진정/섬망 치료/근이완제의 이해, Nutrition support/Fluid/electrolyte/acid-base disorders의 이해, 혈역학적 모니터링/인공호흡기/신대체요법 및 체외막산소화 기계의 이해, Physical examination, 각종 수술 및 시술에 대한 이해, 호흡기계/심혈관계/신경계/신장계/위장관 및 간장계/내분비계/혈액계의 병태생리 및 치료의 이해, 감염학/독성학/면역학 등의 이해 등

※ Critical Pharmacy – Board of Pharmacy Specialties

(BCCCP: Board Certified Critical Care Pharmacists)

Ref. Current Status of Pharmaceutical Care in Intensive Care Units in Korea

(조사기간: 2018년 7월~2018년 9월)

In the era of the 4th industrial revolution

- A computerized Adverse Drug Event Alerting System using clinical rules

Table IV. Prospective study results of the Adverse Drug Event Alerting System (ADEAS): the 20 different clinical rules responsible for the 72 true positive alerts

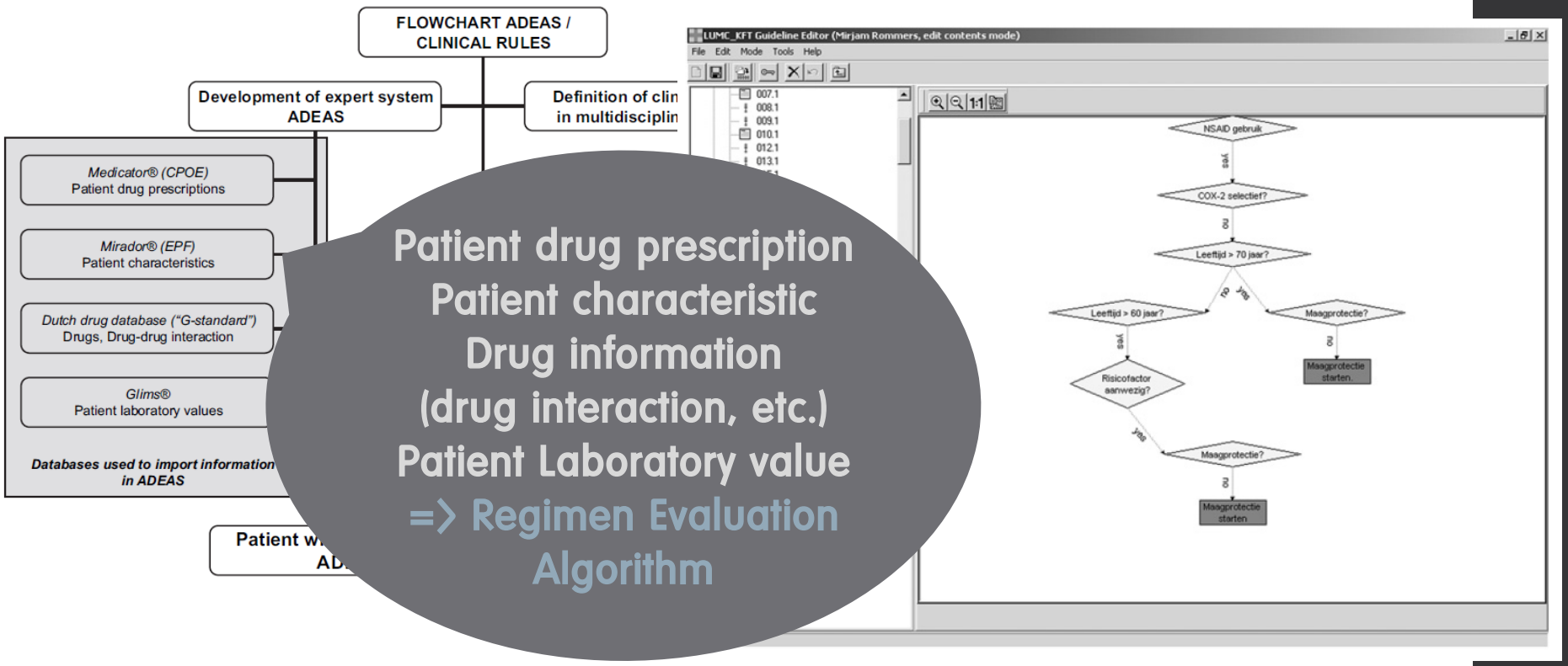
Clinical rule	No. of patients with alert (A)	No. of patients with real potential ADE [true positive] (B)	No. of interventions (C)	PPV for real potential ADE [true positive] (B/A)	PPV for intervention (C/B)
Patient with CL_{CR} <50 mL/min or plasma creatinine >150 μmol/L	12	12	0[a]	1.00	0.00
Patient with therapeutic drug monitoring result of aminoglycoside or vancomycin therapy	8	8	2	1.00	0.25
Opioid receptor agonist prescribed more than 2 days ago, and no laxative added to the therapy to alleviate constipation	8	8	0[b]	1.00	0.00
Patient with plasma creatinine rise >50% or >50 μmol/L	10	7	1	0.70	0.14
Patient with low molecular weight heparin and CL_{CR} <25 mL/min	4	3	1	0.75	0.33
Patient >70 years of age prescribed an NSAID (not COX-2 selective) and has no ulcer protection, or patient >60 years of age prescribed an NSAID (not COX-2 selective) with an additional risk factor for ulcer and has no PPI	3	3	2	1.00	0.67
Patient (>70 years) with digoxin (>0.125 mg/day) or patient (>70 years) with digoxin and CL_{CR} <50 mL/min or creatinine rise >50% or >50 μmol/L	3	2	2	0.67	1.00
Patient with ciprofloxacin or norfloxacin and antiepileptic agents	2	2	0	1.00	0.00

Ref. Drug Saf 2011; 34(3): 233-242

In the era of the 4th industrial revolution

- Development of a computerized alert system, ADEAS,

  to identify patients at risk for an adverse drug event



Ref. Qual Saf Health Care 2010; 19: e35

Impact of CPOE & CDSS

Impact of commercial computerized provider order entry (CPOE) and clinical decision support systems (CDSSs) on medication errors, length of stay, and mortality in intensive care units: a systematic review and meta-analysis

Journal of the American Medical Informatics Association, 24(2), 2017, 413–422
doi: 10.1093/jamia/ocw145
Advance Access Publication [illegible] October 2016

ABSTRACT

Objective: To conduct a systematic review and meta-anal
vider order entry (CPOE) and clinical decision support
(LOS), and mortality in intensive care units (ICUs).
Methods: We searched for English-language literature pu
ing Medline, Embase, and CINAHL. Titles and abstracts of 58
cluded if they: (1) reported results for an ICU population; (2) eva
CDSSs to an existing CPOE system; (3) reported quantitative data on me
hospital LOS,
ICU mortality, and/or hospital mortality; and (4) used a randomized controlled trial or quasi-experimental study

Results: Twenty studies met our inclusion criteria. The transition from paper-based ordering to commercial CPOE systems in ICUs was associated with an 85% reduction in medication prescribing error rates and a 12% reduction in ICU mortality rates. Overall meta-analyses of LOS and hospital mortality did not demonstrate a significant change.

Discussion and Conclusion: Critical care settings, both adult and pediatric, involve unique complexities, making them vulnerable to medication errors and adverse patient outcomes. The currently limited evidence base requires research that has sufficient statistical power to identify the true effect of CPOE implementation. There is also a critical need to understand the nature of errors arising post-CPOE and how the addition of CDSSs can be used to provide greater benefit to delivering safe and effective patient care.

CPOE & CDSS
in ICU
=> ME 85% ↓
ICU mortality 12% ↓

Impact of CPOE & CDSS

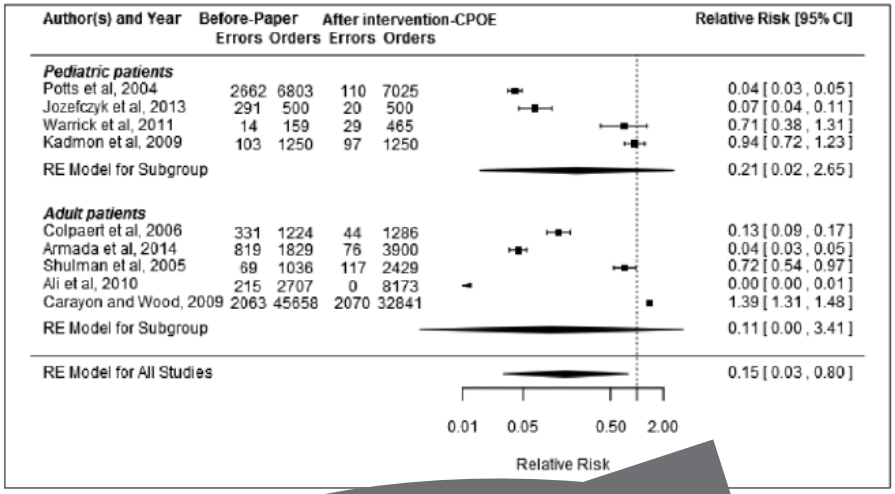


Figure 2. Relative risk of medication errors (e... ...dom effect).

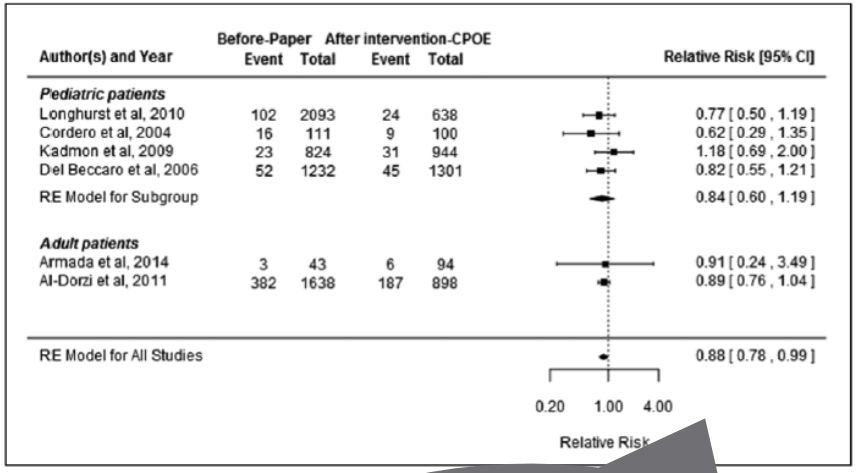


Figure 4. Relative risk of ICU mortality (event indicates number of d...

RR of Medication Errors
0.15(0.03-0.80)
cf. ICU LOS
-0.1(-0.81-0.60)

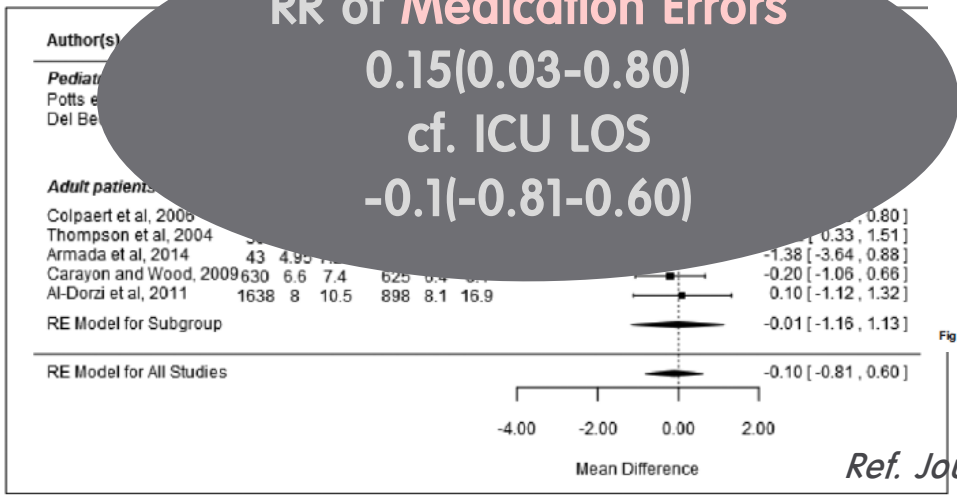


Figure 3. Mean difference of ICU LOS (N indicates number of patients and mean indicates LOS in days; RE = random effect).

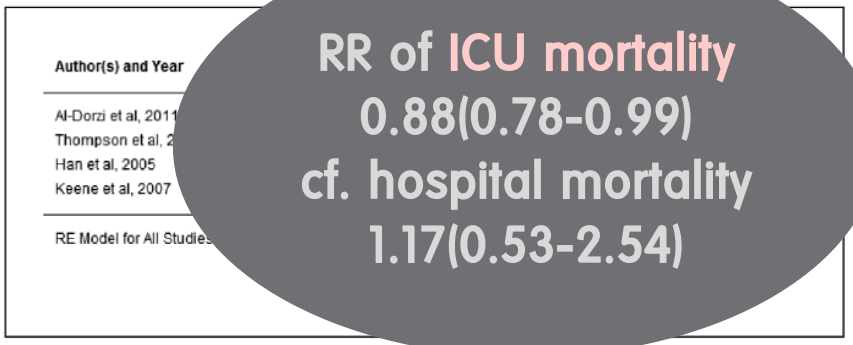


Figure 5. Relative risk of hospital mortality (event indicates number of deaths and total indicates number of patients; RE = random effect).

RR of ICU mortality
0.88(0.78-0.99)
cf. hospital mortality
1.17(0.53-2.54)

Ref. Journal of the American Medical Informatics Asso...
2017; 24(2): 4...

Smart Infusion Pump

- **Infusion pump → smart infusion pump**

- Include Software programs

  (dose error reduction systems (DERS) and drug libraries)

* Drug libraries:
  - predefined parameters for drug type, strength, dosing limits of specific drugs
  - usually customized for each hospital's practice, tailored for specific care units
* Include Clinical advisories and Alert indications

=> Reduction in errors related to oversight & miscalculated doses

Ref. Drug Saf 2014; 37: 1011-1020

Smart Infusion Pump

- Smart infusion pumps reduce IV medication administration errors

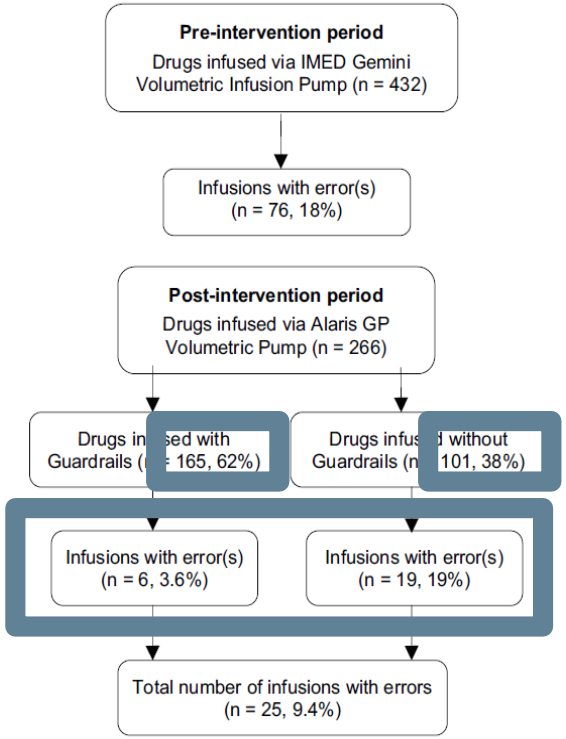


Figure 1. Distribution of errors during the pre- and post-intervention periods.

Ref. J pharm Pract Res. 2011; 41(3): 192-5

Table 2. Intravenous drugs administered in the pre- and post-intervention periods

Drugs	Pre-intervention (n = 432)	Post-intervention (n = 266)
Anaesthetics: propofol	43 (10%)	26 (9.8%)
Antibacterials, antivirals, antifungals: aciclovir, azithromycin, ciprofloxacin, dicloxacillin, fluconazole, gentamicin, linezolid, metronidazole, vancomycin	61 (14%)	54 (20%)
Anticoagulants, antiplatelets: abciximab, danaparoid, heparin, infliximab, tirofiban	62 (14%)	27 (10%)
Electrolytes: magnesium, phosphate, potassium	109 (25%)	67 (25%)
Inotropes: adrenaline, dobutamine, milrinone, noradrenaline, vasopressin	98 (23%)	44 (16%)
Analgesics: paracetamol; antidotes: acetylcysteine; cardiac: amiodarone; endocrine: octreotide; gastroenterology: pantoprazole; obstetrics and gynaecology: oxytocin, salbutamol	59 (14%)	48 (18%)

Table 3. Clinical significance of the errors associated with intravenous infusions

	Clinical significance rating			
	Low	Moderate	High	Extreme
Pre-intervention (n = 432)	43 (10%)	2 (0.5%)	30 (6.9%)	1 (0.2%)
Post-intervention (n = 266)	16 (6%)	5 (1.9%)	4 (1.5%)	0
Post-intervention without Guardrails (n = 101)	13 (13%)	2 (2%)	4 (4%)	0
Post-intervention with Guardrails (n = 165)	3 (1.8%)	3 (1.8%)	0	0

Smart Infusion Pump

- Examples of potentially fatal errors prevented

Table 6. Potential errors intercepted by IV medication safety system

The following are 2 examples of potentially harmful errors that were prevented by nurses using the IV safety software and re-

- Norepinephrine drip programmed at 100 times the intended dose.
  - -Warning message displayed when nurse attempted to start infusion.
  - -System was reprogrammed before infusion started.
  - -Impact if no safety system—Patient in critical care on continuous monitoring.
  - -Nurse may detect the error, if subsequent dosing is closely based on change in condition.
- Heparin drip programmed 13 times the intended dose.
  - -Warning message displayed when nurse attempted to start infusion.
  - -System was reprogrammed before infusion started.
  - -Impact if no safety system—Probably 6 hours, when PTT levels were drawn,
  - -Before error would be detected; potentially severe internal bleeding
  - -Likelihood of detection—low.

Ref. Nurs Adm Q. 2015; 29(1): 28-

Smart Infusion Pump

- Impact of Smart Infusion Technology on Administration of Anticoagulants

Table 1
Anticoagulant dose alert limits

Medication	Underdose Limit	Overdose Limit
UFH	<300 U/h	>2,800 U/h
Argatroban	<0.5 μg/kg/min	>10 μg/kg/min
Lepirudin	<5.0 mg/h	>16.5 mg/h
Bivalirudin	<0.2 mg/kg/h	>1.8 mg/kg/h

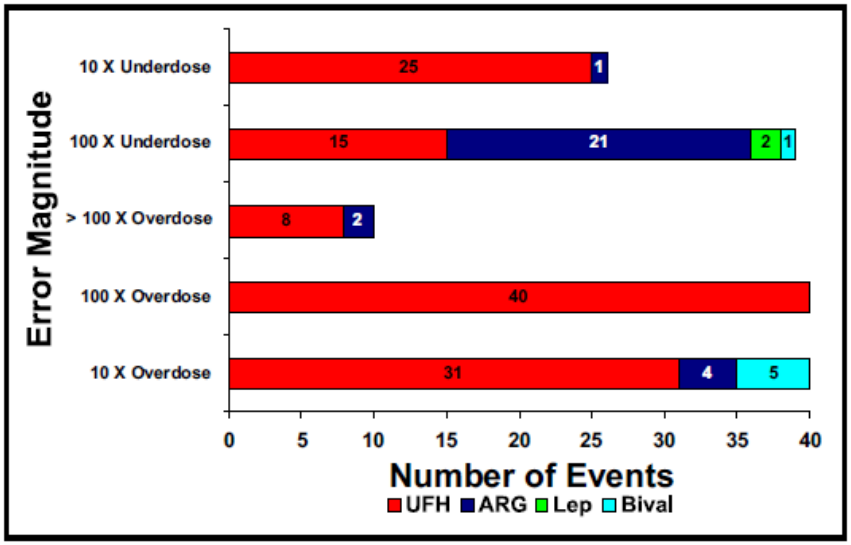


Figure 2. Magnitude of dosing errors. ARG = argatroban; Lep = lepirudin; Bival = bivalirudin.

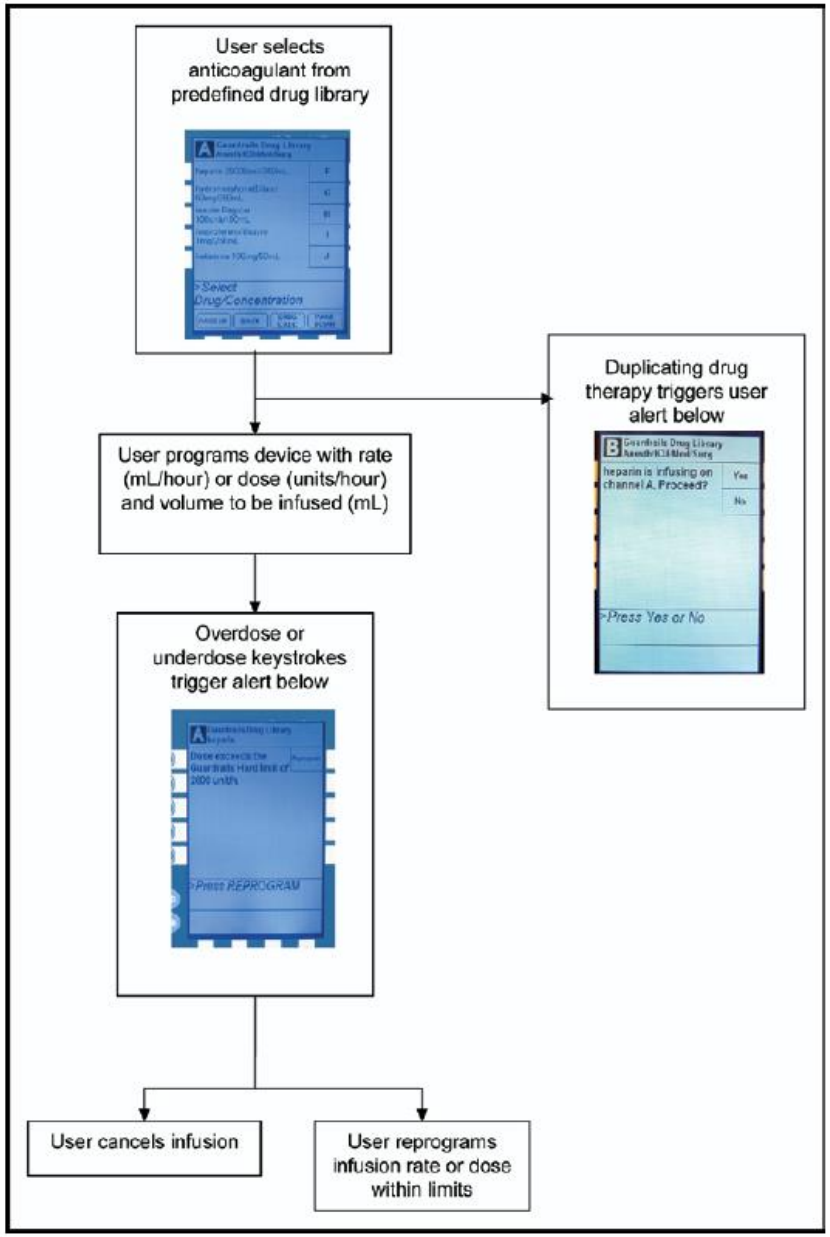


Figure 1. Drug library and user alerts.

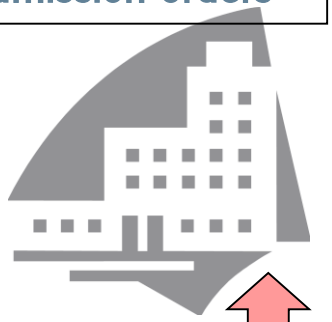
Ref. Am J Cardiol. 2007; 99(7):

Transition of Care: Discrepancy ↑

Discharge orders
41% patients had ≥ 1 discrepancy
23% omissions[5]
Readmission 2.3 x more likely if ≥ 1 med omitted[6]

Medication orders
30-70% patients had discrepancies between history and admission orders[3]

Admission



Discharge

Admission Histories
10-67% contain errors[1]
Up to 1/3 potential adverse drug events (PADEs)[2]

Internal transfer
62% patients had ≥ 1 unintentional discrepancy
36% PADE[4]

Ref. 1. Tam VC, Knowles SR et al, CMAJ 2005, 2. Cornish PL, Knowles SR, Archives Int Med2005, 3. NICE NPSA Tech Bulletin medication reconciliation 2007, 4. Lee J et al Annals Pharmacotherapy 2010, 5.Wong J et al Annals Pharmaco 2009, 6. Stowasser, J Pharm Pract Res 2002

Transition of Care => Med Rec

- **Medication Reconciliation (Med Rec)**

- the standardized process of obtaining
  a patient's best possible medication history and
  comparing it to presentation, transfer or discharge medication orders
  to identify and resolve discrepancies
  in the context of the patient's medication management plan

- More than 50% of ME occur at transitions of care
- Formalized MED REC reduces medication discrepancies (errors)
  by 50 – 94% [1-4]

Ref. 1. Qual Saf Health Care 2006;15:122-6. 2. J Crit Care 2003;18:201-5

3. Patient Saf 2006;32:225-9. 4. J Clin Outcomes Manage 2001;8:27-34

The Role of Critical Care Pharmacist

- Continuously promote qualitative & quantitative development in fundamental, desirable, and optimal activities to ensure effective & safe medication use for the critically ill patients

- As a member of the multidisciplinary team, define, recognize, & perform the role of critical care pharmacist, which reflect the needs of other medical staff

Thank you !