Development of a clinical decision support system for renal dose adjustment and integration into a drug information system with computerized decision support.

Schmitt SPW[1], Kaltschmidt J[1], Bertsche T[1] ,Wetter T[2], Haefeli WE[1]
[1]*Department of Internal Medicine VI, Clinical Pharmacology and Pharmacoepidemiology, University Hospital Heidelberg, Germany*
[2]*Department of Medical Informatics, University Heidelberg, Germany*
simon.schmitt@med.uni-heidelberg.de

Objective: Between 14% and 21% of all inpatients have significant renal impairment [1-3] and approximately one in seven drugs is mainly excreted through the kidneys [4] requiring dose adjustment (usually dose reduction) in renal failure. Parameters such as the patient's weight, age, gender, current renal function and drug specific parameters such as the Q_0-value are required to define the dose and must be considered in the prescription process together with information on availability, price, and divisibility of tablets. Presently, such dose adjustment is only accomplished in 33% of all cases [1,2,5] leading to excess length of stay, risk of adverse reactions [2], and excess drug costs of about 14%. Computerized clinical decision support (CCDS) systems can reduce medication errors, costs, and length of stay [1,6,7] but most of them lack the possibility to carry out all steps required to tailor drug therapy to the patients' needs and to concurrently consider all factors influencing a prescription. The aim of this project was thus to build an electronic system fulfilling most of these prerequisites.
Materials and Methods: Starting with a database for renal drug dose adjustment ([4] and www.dosing.de) created by the Department of Internal Medicine VI, Clinical Pharmacology and Pharmacoepidemiology we developed a knowledge-based system named DosingExpert and integrated it into an existing web-based drug information system ([8] and www.aidklinik.de) with computerized physician order entry (CPOE). The database contains peer reviewed drug dosage information about pharmacologically active agents, renal and adverse drug effects, tablet divisibility, and current drug market data (the latter based on Gelbe Liste Pharmindex**)**. Inpatients' master data and laboratory test results are exchanged real-time with the SAP i.s.h.med hospital information system in place in our institution. Patients' estimated or measured current renal function [9] is combined with newly developed algorithms to determine the best medication, adjust dosage and regimen, and avoid potential harm.
Results: We successfully developed a knowledge-based system for renal dose adjustment and integrated it into the drug information system of the University Hospital of Heidelberg (see fig. 1). Fulfilling the above criteria, this system comprehensively individualizes therapy with more than 650 active ingredients. The severity and urgency of all suggestions is expressed in intuitive colour codes and explicit recommendations to discontinue a drug, adapt its dosing regimen, or change to a therapeutic alternative are clearly displayed. Moreover, the suggestions are linked to the available galenic formulations on the market and their divisibility and immediate background explanation is offered upon request. A web service as part of DosingExpert allows future sharing of this knowledge base using Simple Object Access Protocol (SOAP).
Conclusion: DosingExpert demonstrates that numerical data and a large amount of symbolic information of various types can be seamlessly integrated into an online decision support that safeguards physicians' prescriptions. Because prescription data are available as a control before introduction of the tool, effects on costs, prescription behaviour, clinical workflow, and patient outcome can now be evaluated. Further external systems can be linked to further improve clinical decision support using the standardized communication protocol SOAP.

Fig. 1 – Clinical Decision Support for dose adjustment in renal impairment. The knowledge-based system DosingExpert generates proposals for each drug of the current medication.

Literature

[1] Chertow HM, Lee J, Kuperman GJ, Burdick E, Horsky J, Seger DL, Lee R, Mekala A, Song J, Komaroff AL, Bates WD. Guided medication dosing for inpatients with renal insufficiency. JAMA 2001;286:2839.
[2] Falconnier AD, Haefeli WE, Schoenenberger RA, Surber C, Martin-Facklam M. Drug dosage in patients with renal failure optimized by immediate concurrent feedback. J Gen Intern Med 2001;16:369-75.
[3] Nash IS, Rojas M, Hebert P, Marrone SR, Colgan C, Fisher LA, Caliendo G, Chassin MR. Reducing Excessive Medication Administration in Hospitalized Adults With Renal Dysfunction. Am J Med Qual 2005;20:64-9.
[4] Bertsche T, Haefeli WE. Individualisierte Arzneimitteltherapie bei Patienten mit Niereninsuffizienz. Pharm Ztg 2006;151:718-23
[5] Wong NA, Jones HW. An analysis of discharge drug prescribing amongst elderly patients with renal impairment. Postgrad Med J 1998;74:420-2.
[6] Classen DC et al. Adverse drug events in hospitalized patients. Excess length of stay, extra costs, and attributable mortality. JAMA 1997;277:301-6.
[7] Bates DW, Teich JM, Lee J, Seger D, Kuperman GJ, Luf MN, Boyle D, Leape L. The impact of computerized physician order entry on medication error prevention. JAMIA 1999;6:313-21.
[8] Kaltschmidt J, Gallin S, Haefeli WE. Essential functional requirements for an effective electronic drug information system in a hospital. Int J Clin Pharmacol Ther 2004;42:615
[9] Dettli L. The kidney in pre-clinical and clinical pharmacokinetics. Jpn J Clin Pharmacol Ther 1984;15:241-54.