Quality of requests for serum digoxin concentrations: experience from an Australian Regional Health Service

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What is already known about this subject

- Therapeutic drug monitoring of serum digoxin concentrations (SDC) is considered useful in enhancing the therapeutic benefits of digoxin and minimizing the incidence of adverse drug reactions.
- The quality of requests for SDC has been reported to be generally unsatisfactory. However, studies have focused on few information parameters.
- A better knowledge of these issues might be useful to target appropriate areas of weakness within healthcare systems.

What this study adds

- The poor quality of the information in SDC requests involves a wide range of codes from the contact details of the requester to the time interval between the last dose of digoxin and blood sampling.
- Misuse of the therapeutic drug monitoring service is common across different specialties and healthcare settings.

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Aims

To assess the quality of the information provided with serum digoxin concentration (SDC) requests received by a therapeutic drug monitoring service in a regional health service.

Methods

We conducted a retrospective audit of a consecutive series of 685 SDC requests during a 7-month period. Information regarding (i) contact details, (ii) reasons for request, (iii) dose, (iv) route of administration, (v) concurrent therapy, (vi) treatment duration and (vii) time interval between the last dose and sampling was reviewed and coded as appropriate or inappropriate/missing. Data were analysed according to the origin of request, i.e. from different specialties/wards (emergency department and critical care, cardiology and coronary care unit, medicine and aged care, surgery, and general/private practice) and healthcare settings (teaching hospital, geriatric hospital and general/private practice).

Results

The quality of SDC requests was generally poor across different specialties and healthcare settings. The information provided for the coded parameters was appropriate only in 19.1% (i), 6.4% (ii), 54.7% (iii), 45.8% (iv), 12.8% (v), 32.9% (vi) and 47.1% (vii) of cases. No SDC request was complete in all the information codes. SDC requests from general/private practice lacked more often details regarding the dose (information provided in 46.7% of requests, $P = 0.007$ vs. other specialties; $P = 0.02$ vs. other settings) and the route of administration (20.0%, $P < 0.001$ vs. other specialties and vs. other settings). SDC requests from the emergency department and critical care unit lacked more often details regarding the treatment duration (22.6%, $P < 0.001$ vs. other specialties) and the time interval between the last dose and blood sampling (40.1%, $P = 0.01$ vs. other specialties).

Conclusions

The quality of the information in SDC requests is poor across different specialties and healthcare settings. Educational strategies to ensure the appropriate use of this service are urgently needed.

Introduction

Despite a reduction in the use of digoxin in Australia over the last 15 years (805 796 prescriptions in 1992 *vs.* 472 042 prescriptions in 2005), this positive inotropic and antiarrhythmic agent still plays an important role in the management of congestive heart failure and ventricular rate control in patients with atrial fibrillation [1, 2]. Given its complex pharmacokinetic profile and narrow therapeutic index, therapeutic drug monitoring of serum digoxin concentrations (SDC) is considered useful in enhancing the therapeutic benefits of digoxin and minimizing at the same time the incidence of adverse drug reactions [3–5]. In order to accomplish these goals, however, the provision of appropriate information when requesting SDC is paramount to optimize the interpretation of results and the quality of feedback to the clinician.

The quality of requests for SDC has been reported to be generally unsatisfactory in previous reports [6–10]. These studies, however, have generally assessed a relatively small number of requests over a short period of time. Moreover, no study has investigated differences in the quality of requests originating from different specialties (e.g. medicine *vs.* surgery), settings (e.g. hospital *vs.* primary practice) and period of time when the request was sent (requesting physicians with different levels of training). A better knowledge of these issues might be useful to target appropriate areas of weakness within healthcare systems.

The Southern Adelaide Health Service is a recently established regional service which includes a teaching hospital, a geriatric and rehabilitation hospital and a number of outlying primary care practices and private practices covering a catchment area of about 330 000 people. The aim of this study was: (i) to investigate the overall quality of the information provided in requests for SDC within this healthcare service over a 7-month period; and (ii) to locate the areas that might require educational interventions to promote a better use of the therapeutic drug monitoring service.

Methods

Between September 2005 and March 2006, 700 requests for SDC were received by the therapeutic drug monitoring service of Flinders Medical Centre, a tertiary care referral centre and teaching hospital. The digoxin assays were performed using a micro particle immunoassay technique on an Abbott AXSYM auto-analyser (Abbott Diagnostics, Santa Clara, CA, USA) [11]. In order to assess the quality of the information provided, the following parameters were assessed in each request by a single investigator: (i) requester contact details, (ii)

reasons for request, (iii) digoxin dose, (iv) route of administration, (v) concurrent therapy, (vi) treatment duration and (vii) time interval between the last dose and blood sampling. The information was coded as either appropriate or inappropriate/missing according to the following criteria [12]: (i) appropriate: surname and contact number; (ii) appropriate: to assess patient compliance; to investigate clinical deterioration after an initial good response; in patients with significant alterations of renal function; when digoxin toxicity is suspected; to evaluate the need for continued digoxin therapy; when conditions known to alter the therapeutic response to digoxin (e.g. thyroid disease); and when there is a suspected drug interaction; (iii) appropriate: dose in mg or µg; (iv) appropriate: oral or intravenous; (v) appropriate: drug name and daily dose; (vi) appropriate: duration of digoxin treatment in days/months or time since dose change was made; (vii) appropriate: >6 h post dose.

Data were also analysed according to the origin of request, i.e. from different specialties (i.e. emergency department and critical care, cardiology and coronary care unit, medicine and aged care, surgery, and general/private practice) and settings (teaching hospital, geriatric hospital and general/private practice). The information parameters coded were similar in the SDC requests originating from different locations. The influence of the time of request from general medicine and aged care (e.g. late 2005 *vs.* early 2006) was also analysed. In these specialties there is a new intake of junior medical staff at the beginning of each calendar year. Therefore, differences, if any, in the level of training were also assessed. The study was performed in accordance with the Declaration of Helsinki. No ethics committee approval was sought as this was a retrospective audit.

Statistical analysis

Data are presented as ratios and percentages of the cases where the appropriate information was provided. Comparisons between groups were performed by χ^2 test with Fisher's correction when appropriate. The impact of the time of request on the quality of information provided (i.e. appropriate *vs.* inappropriate/missing) was assessed by backward binary logistic regression analysis (SPSS for Windows 11.0; SPSS Inc., Chicago, IL, USA). A *P*-value <0.05 indicated statistical significance.

Results

Fifteen SDC request forms could not be found. The remaining 685 forms were analysed and served as the basis for the final data analysis (443 SDC requests, 64.7%, were received between 1 September and 31

Table 1

Appropriateness of serum digoxin concentration requests from different specialties

	Emergency/ Critical Care	Cardiology/ CCU	Medicine/ Aged Care	Surgery	General/ Private Practice	P-value
Contact details	36/274 (13.1%)	11/63 (17.5%)	43/250 (17.2%)	12/64 (18.8%)	29/30 (96.7%)	<0.001
Reason	16/274 (5.8%)	8/63 (12.7%)	14/250 (5.6%)	9/64 (9.4%)	0/30 (0.0%)	0.107
Dosage	131/274 (47.8%)	44/63 (69.8%)	145/250 (58.0%)	38/64 (59.4%)	14/30 (46.7%)	0.007
Route of administration	108/274 (39.4%)	36/63 (57.1%)	126/250 (50.4%)	35/64 (54.7%)	6/30 (20.0%)	<0.001
Concurrent therapy	35/274 (12.8%)	12/63 (19.0%)	33/250 (13.2%)	4/64 (6.3%)	3/30 (10.0%)	0.298
Treatment duration	62/274 (22.6%)	25/63 (39.7%)	99/250 (39.6%)	30/64 (46.9%)	8/30 (26.7%)	<0.001
Time since last dose	110/274 (40.1%)	39/63 (61.9%)	122/250 (48.8%)	33/64 (51.6%)	17/30 (56.7%)	0.010

Percent values indicate the proportion of correct details provided for each coded variable. CCU, Coronary Care Unit.

Table 2

Appropriateness of serum digoxin concentration requests from different settings

	Teaching Hospital	Geriatric and Rehabilitation Hospital	General/ Private Practice	P-value
Contact details	88/518 (17.0%)	15/137 (10.9%)	29/30 (96.7%)	<0.001 0.134*
Reason	35/518 (6.7%)	9/137 (6.6%)	0/30 (0.0%)	0.340 0.941*
Dosage	271/518 (52.3%)	89/137 (65.0%)	14/30 (46.7%)	0.020 0.163*
Route of administration	229/518 (44.2%)	78/137 (56.9%)	6/30 (20.0%)	<0.001 0.119*
Concurrent therapy	71/518 (13.7%)	14/137 (10.2%)	3/30 (10.0%)	0.500 0.339*
Treatment duration	162/518 (31.3%)	56/137 (40.9%)	8/30 (26.7%)	0.070 0.141*
Time since last dose	231/518 (44.6%)	75/137 (54.7%)	16/30 (53.3%)	0.080 0.210*

Percent values indicate the proportion of correct details provided for each coded variable. *Teaching vs. Geriatric and Rehabilitation Hospital.

December 2005, whereas 242, 35.3%, were received between 1 January and 31 March 2006).

The quality of SDC requests was generally poor across different specialties and settings (Tables 1 and 2). The information provided was appropriate in only

19.1% of requests for parameter (i), 6.4% for (ii), 54.7% for (iii), 45.8% for (iv), 12.8% for (v), 32.9% for (vi) and 47.1% for (vii). No SDC request was complete in all the information codes. Information regarding the contact details was present in virtually all (96.7%) requests

originating from general and private practices (Tables 1 and 2). This is not surprising, as this information is automatically printed by the local practice clerical staff. On the other hand, SDC requests from general/private practices more often lacked details regarding the dose (information provided in 46.7% of requests, $P = 0.007$ vs. other specialties; and $P = 0.02$ vs. other settings) and the route of administration (20.0%, $P < 0.001$ vs. other specialties and other settings). SDC requests from the emergency and critical care departments lacked more often details regarding the treatment duration (22.6%, $P < 0.001$ vs. other specialties) and the time interval between the last dose and blood sampling (40.1%, $P = 0.01$ vs. other specialties) (Tables 1 and 2). There were no significant differences in the quality of SDC requests between the teaching and the geriatric hospital (Table 2). SDC requests from general medicine and aged care in early 2006 were more likely to include the contact details [odds ratio (OR) 2.2, 95% confidence interval (CI) 1.1, 4.2; $P = 0.024$], the reason for the test (OR 3.6, 95% CI 1.1, 12.0; $P = 0.033$) and the concurrent therapy (OR 3.2, 95% CI 1.5, 6.9; $P = 0.003$) when compared with the requests sent late in 2005.

Discussion

The results of this study show that the quality of requests for SDC within a regional health service is generally poor. None of the 685 requests audited was complete in all the required details. Although the forms originating from general and private practice more often lacked important information, the problem also involved medical specialties, whose staff are expected to be familiar with the pharmacokinetics of digoxin and the principles of therapeutic drug monitoring. For example, information on concurrent therapy, treatment duration, and time interval between the last dose and blood sampling on requests originating from cardiology and coronary care unit wards was present in only 19.0%, 39.7% and 61.9% of cases, respectively. The Medicare Schedule Benefit fee for a single SDC is AU\$18.45 (£7.36). As the information regarding treatment duration and time interval since the last dose, two crucial parameters for an adequate test interpretation, was appropriate in only 32.9% and 47.1% of SDC requests, we estimate an annual loss due to inappropriate request details of AU\$14 549 (£5803) and AU\$11 450 (£4567), respectively, for this single service. Assuming similar trends nationally, poor SDC requesting, resulting in uninterpretable digoxin levels, wastes several million dollars per year in Australia.

Previous reports published over the last 25 years have assessed the quality of the digoxin therapeutic monitor-

ing services [6–10]. Clague *et al.* audited 200 consecutive requests for SDC in a teaching hospital [9]. The reason for requesting the test could not be determined in 82.5% of cases [9]. Gibb *et al.* audited 285 SDC requests over 12 weeks [7]. In 24% of cases there was no clear indication for the request. Moreover, in 49% of cases the time interval between the last dose and the sampling was either unknown or inappropriate [7]. Makela *et al.* evaluated 134 SDC requests [10]. The indication for the request was missing in 18.7% of cases [10]. Kumana *et al.* reviewed 172 SDC requests and observed that the information on the time elapsing between the last dose and blood sampling was lacking in 31.4% of cases [8]. More recently, Sidwell *et al.* reviewed 100 consecutive SDC requests over 2 months [6]. In 53% of cases there was no clear indication for the request [6]. Overall, these reports have shown significant flaws in the information provided to the therapeutic drug monitoring service, in particular regarding the indications and the time interval between the last dose of digoxin and blood sampling. Although these studies were performed in different countries, there was no trend towards an improvement in the quality of SDC requests over time.

The results of our study provide some additional points worthy of discussion. First, the lack of details in SDC requests is not limited to the reasons for the test or the time interval between the last dose and blood sampling, but it rather involves a wide spectrum of parameters, some of which are essential to provide a correct interpretation of the test. Second, the poor quality of requests was a common finding across different specialties and settings. Third, the quality of requests from medicine and aged care in early 2006 was higher when compared with those sent in late 2005. New residents and interns starting their yearly rotation in January are provided with an electronic copy of the hospital Medicine Handbook, which contains the guidelines for the therapeutic drug monitoring of digoxin. Our results seem to indicate that the lack of an appropriate educational reminder strategy throughout the year might, at least partly, explain the poorer quality of requesting later in the year. This hypothesis, however, requires further testing, as the same group of trainees was not followed for a whole year.

What strategies could be adopted to improve the quality of requests for SDC, as well as other aspects related to the use of therapeutic drug monitoring in clinical practice? Traditional educational approaches, such as lectures and tutorials, can improve practice but they are labour-intensive and their effects wane with time [13]. Multidisciplinary quality-improvement projects and the development of critical pathways and guidelines offer

additional opportunities for education. In this context, effort should be spent in changing common attitudes amongst hospital staff, which often see laboratory services as a utility rather than as professional colleagues [14]. Computerization of requests, where the requesting individual writes orders directly on-line, offers the opportunity for decision support, including reminders and feedback at the time of orders writing. This might represent an attractive option, as it would force the requesting physician to enter the details required for the order to be processed. This tool has been shown to be particularly effective in changing ordering behaviour and is likely to become widely available in developed countries [15].

In conclusion, the quality of SDC requests remains poor in different healthcare settings. The adoption of either a multidisciplinary educational approach and/or computerized requesting methods might offer a useful tool to improve the use of the therapeutic drug monitoring service. This, however, warrants further interventional studies to assess the cost-effectiveness of each intervention.

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