An Automatic Ampoule Dispensing System
Improved Injection Dispensing†1

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Yokohama City University Medical Center was renovated in January 2000 and a total ordering system was established. To improve the dispensing work for injections, an automatic ampoule dispensing system, which picks up injections automatically according to an individual prescription, was introduced. We investigated the effectiveness of the automatic ampoule dispensing system regarding the progress of pharmaceutical services in medical wards.

We improved the automatic ampoule dispensing system twice after its initial deployment. The number of prescriptions for injections, inpatients, the time required for prescription printing, the time required for dispensing, the number of dispensing errors found and inquiries regarding the prescriptions were counted for 12 months. After the first improvement, the dispensing time required was shortened by 25% by changing the manner of transmission of the prescription data. The printing time was shortened by 45% by employing a high-speed printer. The number of inquiries regarding prescriptions increased by eightfold with the saving of the time required for the dispensing itself.

The introduction of the automatic ampoule dispensing system was thus found to be useful in order to save time related to dispensing work and thereby improving the quality of pharmaceutical services for inpatients.

Keywords total ordering system, injection dispensing, automatic ampoule dispensing system, inquiry, risk management

Introduction

Injection dosage forms have the following features: 1) they are used for patients showing sudden changes in condition; 2) frequent changes of prescription; 3) rapid response and high risk; 4) problems of stability on admixing with other injections; and 5) are expensive compared with drugs for internal use and external preparations. In Japan, injections are generally provided to medical wards as a fixed set or as a box filled with ordered injections. Recently, there has been a move toward dispensing of injections according to individual prescriptions. In medical wards, medical errors concerning injections such as misreading of drug name and over-medication can occur, and the participation of pharmacists in minimizing the risk of such errors is required. The Japanese Society of Hospital Pharmacists has proclaimed that supply of injections must be dependent on a prescription, and to improve the quality of injection dispensing has published “The Injection Dispensing Guidelines for Inpatients”1). Injection dispensing2) consists of prescription order,
checking and inquiry regarding the prescription, collection or admixing, audit and delivery. In risk management, the pharmacist has an important role in not only prevention of prescription errors and dispensing errors but also in checking of the dose of medication\(^3\), drug interactions and intravenous drip speed etc.\(^4\)

When Yokohama City University Medical Center was renovated in Jan. 2000, we introduced the use of an automatic ampoule dispensing system as part of the total ordering system of the hospital. The automatic ampoule dispensing apparatus linked directly to the total ordering system is useful for rationalization of work and for prevention of human errors\(^5\),\(^6\). In this study, we tried to shorten the dispensing time by the rationalization of dispensing work derived from introduction of this system. Moreover, we attempted to ensure sufficient time was available for checking of prescriptions and to offer information regarding the injections to physicians.

**Methods**

1. **Outline of the injection ordering system and the automatic ampoule dispensing apparatus**

An outline of the injection ordering system (NEC Corp., Tokyo, Japan) and the injection dispensing system is shown in Fig. 1 (Stage 1). The prescriptions ordered by a physician in the medical ward are recorded in the database of the total ordering system. The pharmacist confirms the orders in a terminal display, prints prescriptions and transmits the orders to a dispensing support system (Yunicom X; Yuyama Co., Ltd, Osaka, Japan). The dispensing support system checks for the possibility of interactions between the injections prescribed and internal preparations. Then, the data are transmitted to the reception computer of the automatic ampoule dispensing system (Central Uni Co., Ltd, Fukuoka, Japan). The reception computer receives the prescription data and prepares discharge data in the dispensing support system server. After receiving the data from the reception computer, the dispensing support system server totals the data and directs to output various lists and transmits the data to the automatic ampoule dispensing apparatus. Yokohama City University Medical Center has two automatic ampoule dispensers (AAD 144 R-MC; Central Uni Co., Ltd). Although loading of 144 cassettes is possible for each machine, the number of drugs loaded was set to 115 types (129 cassettes). According to the prescription data, the automatic ampoule dispensing apparatus picks up and fills the ampoules into a

![Fig. 1. Dispensing System for Injections in Stage 1, 2 and 3.](image-url)

The automatic ampoule dispensing apparatus carried 115 types of injections using 129 cassettes in Stage 1 and 2 and 101 types of injections using 122 cassettes in Stage 3.

A : Data from ordering system  
B : Extraction of general order  
C : Used data  
D : Audit system  
*: Automatic ampoule dispensing
In Yokohama City University Medical Center, injection dispensing is carried out 3 times a day at 9:30, 14:00, and 16:00 on weekdays. No dispensing is carried out at the weekend (Saturday, Sunday, Monday) or on national holidays. Three pharmacists perform for injection dispensing (exclusive duty) during the morning and at 16:00, and five pharmacists are on duty at 14:00. Injections for weekend use are prepared on Friday and delivered to the medical ward on the appropriate day. The order deadline is 8:00 on Friday and the dispensing work is started from 8:30. Acceptance of delayed orders is closed at 14:00, dispensed with the prescriptions revised between 8:00 and 14:00 and delivered to the medical ward. For prescription printing, dot-matrix system impact printer (Multi Impact 700JX, NEC Corp.) is used for weekdays and two similar printers are used for the weekend.

2. Improvement in prescription data transmission

A trial to improve transmission speed by reduction of the burden on the dispensing support system was performed. In the original system, the arrangement and totaling of data were performed by the dispensing support system then the data were transmitted to the reception computer (Stage 1). In the next stage (Stage 2 in Fig. 1), the system was improved so that the prescription data were transmitted to the reception computer for each group and totaled at the reception computer. Thus, the number of types of terminals used, three in the system former, was reduced to two in the new system; those belonging to the injection ordering system and to the injection dispensing system.

3. Introduction of a high-speed printer and modification of medicine loading into the automatic ampoule dispensing apparatus cassettes

In injection dispensing, the dispensing time of the automatic ampoule dispensing apparatus and the printing time of the prescription are rate-determining steps. To shorten the prescription printing time, a high-speed printer (Multi Impact 700EX, NEC Corp.) was introduced instead of the conventional printer (Multi Impact 700JX, NEC Corp.), and the effect was evaluated. One high-speed printer was used for weekdays and two similar printers were used for the weekend. Furthermore, modification of medicine loading into the automatic ampoule dispensing apparatus, and the layout of loading cassettes was reevaluated with the number of medicines loaded reduced to 101 types (122 cassettes) (Stage 3 in Fig. 1).

4. Items selected for surveillance

   1) Number of inpatients

   Using the total ordering system, the daily number of occupied beds (inpatients) was counted from Jun. 2000, when all floors of the hospital were opened, to Jul. 2001. Counting was limited to the general wards, while the emergency ward, ICU, CCU and burn center to which injections were not supplied by the automatic ampoule dispensing system were omitted.

   2) Number of prescriptions for injections

   The daily number of prescriptions for injections dispensed was counted for one year from Jun. 2000. The prescriptions were classified as regular prescriptions in the morning (1st time), 14:00 (2nd time) and 16:00 (3rd time), canceled prescriptions and revised prescriptions, and counted separately.

   3) Time required for injection dispensing

   The time required for injection dispensing in the morning (1st time), which comprises the major part of the work, was measured. Time recording was performed at the start of work, the start of data transmission to the dispensing support system, the start and finish of data transmission to the automatic ampoule dispensing system, and at the start and finish of the automatic ampoule dispensing apparatus operation. The prescription printing time was also measured. After improvement of the system (Stage 2, Stage 3), similar measurements were performed.

   The period of measurement on weekdays (from Monday to Thursday) was from Oct. 25 to Dec. 25, 2000, as Stage 1, from Jan. 4 to Mar. 5, 2001, as Stage 2 and from May 29 to Jul. 24, 2001, as Stage 3. The measurement for weekend dispensing (Friday) was performed separately during the same period.

   4) Trouble and errors with the injection dispensing system

   Trouble and errors with the injection dispensing system were classified as those due to the automatic ampoule dispensing apparatus (packing space and tray server), breakage of preparations, miscounting of preparations, data transmission errors and maintenance work (supply of bags and ink ribbon). The measurement was performed from Oct. 27 to Dec. 25, 2000, as Stage 1, from Jan. 4 to Mar. 2, 2001, as Stage 2 and from May 29 to Jul. 25, 2001, as Stage 3, including weekend dispensing work.

   5) Number of inquiries in injection prescription audit

   The nature of inquiries in the audit of injection prescriptions and errors found in the dispensing were analyzed. The inquiries were classified into seven categories, i.e. dose, directions for use, incompatibility, expense, ordering system, delivery and others, and the numbers of incidents before and after improvement of the system were compared.
Results and Discussion

1. Changes in number of inpatients and injection prescriptions

After reopening of the hospital on Jan. 1, 2000, the number of inpatients increased gradually. When operation of all the floors began on Jun. 1, 2000, the number of inpatients was 527±13 (mean±S.D.). One year later, the number of inpatients was 584±15, representing an increase of approx. 10%. However, a large change of the number was not observed during the investigation. The monthly change in the mean number of injection prescriptions is shown in Fig. 2.

In the initial three months before the hospital was fully-open, the mean number of prescriptions was 187±7. This became 230±15 in Jun. 2000, when all floors were opened, and increased to 250±12 one year later. The prescription number in the morning was about 80-90% of the whole and did not change throughout the year. Therefore, the prescription number in the morning was used as the index.

2. Working time of each process in the automatic injection dispensing system

In Step 1, the time from the start of transmission to acceptance of data at the reception computer of the automatic ampoule dispensing system was shortened in Stage 2. In Stage 3, although the time was slightly shortened the difference was not significant. The times from the start of data transmission to the end of automatic ampoule dispensing apparatus operation (dispensing time) in Stages 1, 2 and 3 were 117±10min, 106±13min and 85±7min, respectively. The calculated dispensing times per prescription in each stage are shown in Fig. 3. The dispensing time per prescription was 34±3s in Stage 1, 26±4s in Stage 2, and 23±2s in Stage 3. The shortening effect per prescription, approx. 8s in Stage 2 and 11s in Stage 3, was obtained by improvement of the system (p<0.005). Although the same transmission system was used in Stage 2 and Stage 3, the time was reduced by about 3s, possibly because of decreased number of drugs loaded into the automatic ampoule dispensing apparatus and modification of the layout of the cassette. Similarly, the dispensing time per prescription at the weekend was shortened from 26±2s in Stage 1 to 19±2s in Stage 2 and 20±1s in Stage 3.

The printing time per prescription on weekdays was 31±3s in Stage 1 and 30±3s in Stage 2; there was no significant difference between the stages. This result suggested that the time saving effect was mainly due to improvement of the data transmission system. In the dispensing work at Stage 2, the printing time became the rate-determining step of the whole procedure as the dispensing time became

Fig. 2. Time Course of Changes in Number of Prescriptions in the Morning.
Data represent means ± S.D.

Fig. 3. Dispensing Time and Printing Time Per Prescription at Each Stage.
Data represent means ± S.D.
shorter than the printing time. The printing time per prescription was shortened by approx. 13s in Stage 3 as compared to Stage 2, suggesting that the introduction of the high-speed printer played a role in the overall improvement in efficiency of the system. The printing time per prescription on weekends was 21±2s in Stage 1, 23±3s in Stage 2 and 13±1s in Stage 3, showing the same tendency as observed on weekday work. As two printers were used on weekends, the printing time per prescription was shorter than that on weekdays.

3. Occurrence of trouble and errors with the automatic ampoule dispensing system

At the introduction of the automatic ampoule dispensing system, reliability of the apparatus was considered to be an important factor as it could be a source of dispensing errors. Table 1 shows the number of incidences of problems and errors concerning the injection dispensing system in each Stage. The numbers of incidences of problems and errors per day in Stage 1, Stage 2 and Stage 3 were 3.3, 3.9 and 3.0, respectively, and the differences between stages were not significant. On the other hand, the occurrence of transmission errors was reduced from 17 cases (9 days, Stage 1) to nil in Stage 2. This result was considered to have been due to the reduction in dispensing support system work. However, the numbers of incidences of problems and errors per day on weekends were 5.6 in Stage 1 and 7.9 in Stage 2. These numbers were more than double those on weekdays and coincided with the fact that the amount of dispensing work for weekends is threefold greater than that of weekdays.

4. Audit of injection prescriptions

Fig. 4 shows the results of inquiries to other departments by pharmacists concerning prescription contents, ordering system and delivery. Although the numbers of inquiries were only one case in Jun., 2000, and two cases in Jul., 2000, after opening all floors of the hospital, the number of inquiries increased remarkably to 22 cases in Jan., 20 cases in Feb., 31 cases in Mar. and 34 cases in Apr., 2001, in Stage 2. The same tendency was observed in Stage 3, and there were large number of inquiries about dose and incompatibility. The inquiries in Jul. consisted of 15 cases (54%) regarding dose and 11 cases (40%) regarding incompatibility. Improvement of the injection dispensing system brought about an increase in number of inquiries, and the major in-

| Table 1. Number of Days with Problems and Errors in the Injectable Drug Dispensing System. |
|-----------------------------------------------|-------------|-------------|-------------|
| Stage 1 | Stage 2 | Stage 3 |
| AAD machine trouble | 26 (57) | 22 (100) | 23 (62) |
| Breakage of preparation | 7 (7) | 12 (15) | 13 (18) |
| Miscount of preparation | 15 (49) | 20 (40) | 18 (41) |
| Transmission obstacle | 9 (17) | 0 (0) | 3 (3) |
| Number of prescriptions* | 242±16** | 265±47** | 250±19** |

( ) : Total number of incidents
* : The number in the morning of the measurement term
** : mean ± S.D.
queries concerned dose and incompatibility. These results suggested that pharmaceutical checking for injection prescriptions was carried out more actively as compared with before introduction of the automatic ampoule dispensing system.

The new concept for injection dispensing work has become more popular, and the number of hospitals practicing it is increasing. A number of studies with the aim of raising the quality of such work by enrichment of the checking function concerning drugs, dose, drug interactions and incompatibility have been reported. The participation of pharmacists in the prescribing process should help prevent medical errors and have a good pharmaco-economic effect.

Further studies of the detail of injection dispensing including auditing for proper use of drugs should be carried out.

References


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