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Computer-aided Monitoring of Surgical Pathology Workflow

*Chih-En Tseng[1,2], Chin-Lon Lin[2,3], Shi-Shie Huang[4], Kuan-Chung Lin[4], Shu-Mei Chang[1], Sou-Hsin Chien[2,5]**

[1]*Department of Anatomic Pathology, Buddhist Dalin Tzu Chi General Hospital, Chiayi, Taiwan*
[2]*School of Medicine, Tzu Chi University, Hualien, Taiwan*
[3]*Department of Cardiology, Buddhist Dalin Tzu Chi General Hospital, Chiayi, Taiwan*
[4]*Department of Information Services, Buddhist Dalin Tzu Chi General Hospital, Chiayi, Taiwan*
[5]*Department of Plastic Surgery, Buddhist Dalin Tzu Chi General Hospital, Chiayi, Taiwan*

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Abstract

Objective: To explore the feasibility of computer-aided monitoring of surgical pathology workflow.
Materials and Methods: We analyzed the four subprocesses in the surgical pathologic process: (1) arranging surgical pathology examination to receipt of the examination sheet and sample by the laboratory; (2) receipt of the sample to issuance of the pathology report; (3) issuance of the pathology report to automatic forwarding of positive pathology reports by e-mail to the physician; (4) receipt of the positive report to physician response acknowledging receipt.
Results: About 99.2% of the 20,287 samples arrived at the surgical pathology laboratory within 1 work day after the examination was ordered. The pathological report was finished within 1, 2, 3, and 4 work days in 48.7%, 86.4%, 95.8%, and 98.1% of cases, respectively, and was overdue (over 4 working days) in 1.9% of cases. The two main reasons for overdue reports were decalcification of bone samples (41.7%) and complex processing of samples (37.1%). There were 2239 (11%) positive pathological reports that required automatic computer forwarding; the highest percentage (84.3%) of these was reports of malignancies. Automatic computer forwarding succeeded in 99.6% of cases. Physicians replied to confirm receipt of positive reports within 24 and 120 hours after receipt in 52.4% and 83.6% of cases, respectively.
Conclusion: The use of the computer to monitor surgical pathology workflow is feasible. This method can be used for quality assurance in surgical pathology workflow. (*Tzu Chi Med J* 2009;21(2):140–146)

*Corresponding author. Department of Plastic Surgery, Buddhist Dalin Tzu Chi General Hospital, 2, Min-Sheng Road, Dalin, Chiayi, Taiwan.
E-mail address: p121521@tzuchi.com.tw

1. Introduction

Quality assurance of surgical pathology is a process by which the accuracy, timeliness, and completeness of the pathology report is assured. Typical quality assurance and improvement plans should include five categories of monitoring in the surgical pathology workflow (1). Many published reports on the quality

assurance of surgical pathology mainly focused on one part of the five categories of the process, such as pre-analytic monitoring [2–4], analytic monitoring [5–9], post-analytic monitoring [10–12], turnaround time [13–17], and clinician satisfaction and/or complaints [18]. To our knowledge, there is no report dealing with computer-aided quality assurance of the process from the initial order for the examination to acknowledgment by physicians of receipt of positive pathology reports. This study evaluated computer-aided monitoring of the surgical pathology workflow. We discussed issues related to arranging for a surgical pathology examination by clinicians, delivery of samples and examination sheets to the laboratory, issuance of reports, automatic forwarding by computer of positive reports to the clinicians who ordered the examinations, and the confirmation of receipt of the report by the clinician. We suggest some solutions to problems as well as identify the processes that need to be improved further.

2. Materials and methods

Data from all surgical pathology examinations, a total of 20,287 samples, were collected from January 1, 2007 to December 31, 2007 at Buddhist Dalin Tzu Chi General Hospital in Chiayi, Taiwan. Quality assurance was conducted with computer assistance of the surgical pathological workflow, which was divided into four subprocesses (Fig. 1): (1) from ordering of the surgical pathology examination to receipt of the order sheet and sample by the surgical pathology laboratory; (2) receipt of the order sheet and sample to issuance of the report; (3) issuance of the report to automatic forwarding of a positive report by e-mail to the physician who ordered the examination; (4) receipt of the positive report by the physician to the physician's confirmation of receipt of the report by the laboratory. Our weekly working schedule was from 8:00 am to 5:30 pm, Monday through Friday, and from 8:00 am to noon on Saturday. Work days were from Monday to Saturday; Sunday and public holidays were non-work days. For the first subprocess, "overdue" was defined as after Day 1 (with Day 0 being the day that clinicians arranged for examination and Day 1 being any time prior to 5:30 pm on the following work day (Fig. 1A–D). For the second subprocess, "overdue" was defined as after Day 4 (Day 0 being the day of sample receipt and Day 4 being the deadline for issuing the report) (Fig. 1E–F). During the third subprocess, before the surgical pathologist issued one of the three types of positive reports (malignancy, mycobacterium infection [requiring notification of health authorities), and clinical follow-up), an alarm window automatically warned the pathologist of whether the report was really a positive report. When the report was issued, the patient's name, personal identification number, biopsy site, and pathologic diagnosis were automatically sent by e-mail to the physician who requested the examination. At 8:00 am on the next work day, any positive surgical pathology reports that had failed to be delivered by the automatic forwarding process were printed out and hand-delivered to the physician for a signature. The information department was notified, and the reason for the failure was investigated. The programs were then repaired as shown on the right side of the flowchart in Fig. 2. During the fourth subprocess, physicians received notification within 120 hours after e-mail transfer of the report (even on holidays) by accessing their e-mail box and selecting and opening the positive report. The action of selecting and opening the e-mail report resulted in an automatic reply to the laboratory indicating that the

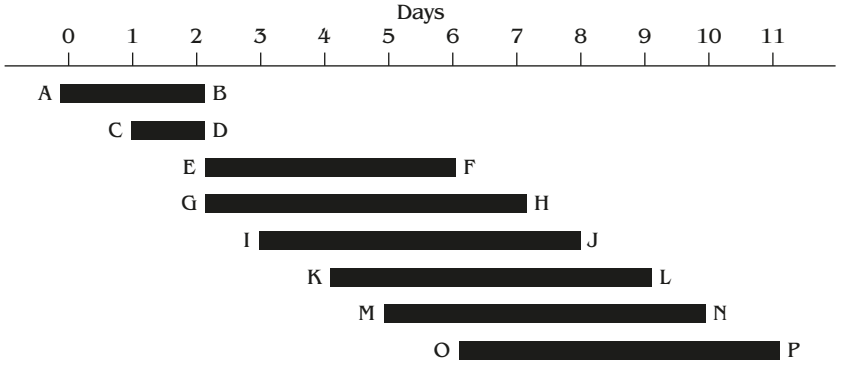

Fig. 1 — Diagram showing the number of days needed to complete each subprocess of the pathology workflow. A–B: sampling and arranging for the pathology examination; C–D: sending samples and examination sheets to and receiving them in the Department of Anatomic Pathology; E: issuance of the report by the pathologist; F: deadline for the issuance of the report; G, I, K, M, O: forwarding positive pathological reports to ordering physicians; H, J, L, N, P: deadline for ordering physicians to respond to the positive report.

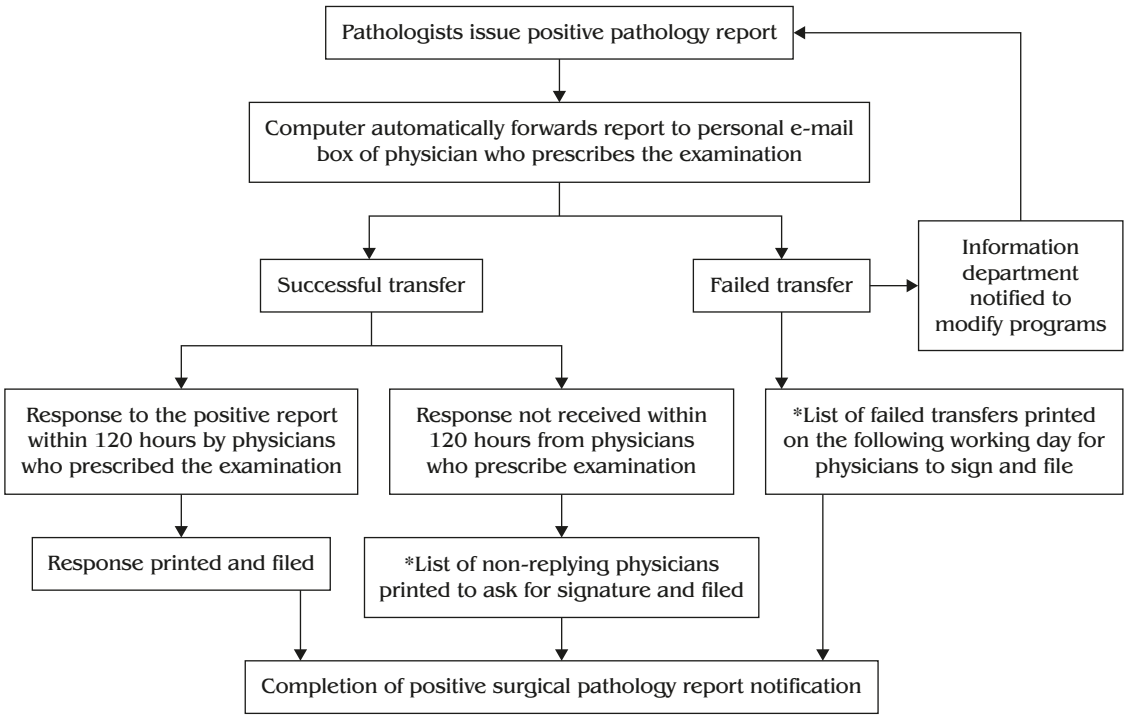

Fig. 2 — Flowchart showing the notification process for positive pathological reports. *In cases of failed automatic computer forwarding or failure to receive a response within the time limit, the date of the report, patient name, identification number, surgical number, biopsy site, and diagnosis were printed out and sent to the physician for a signature.

physician had received the report. Responses later than 120 hours were considered overdue (Fig. 1H, J, L, N, and P are the deadlines for physicians to respond to the positive report). In the absence of a reply, reports (requiring a physician's signature) were printed on the work day after the deadline. By signing, the physician acknowledged receipt of the positive report and the workflow was complete as shown on the left side of the flowchart in Fig. 2.

3. Results

Results of monitoring the first subprocess are shown in Fig. 3. In 2007, 74.0% of samples were delivered on the same day and 25.2% were delivered the day after the examination was arranged (Fig. 3A). Each month, completion of this subprocess was overdue in 0.3–1.0% of cases (Fig. 3B). There were 166 overdue samples annually and the annual overdue rate was 0.8%. Sample delivery was overdue for four reasons. The most common was that clinicians in the outpatient department arranged for the examination more than 1 day in advance of specimen collection (90 cases, accounting for 54.2%). The next most common was administrative errors. For example, errors involving mis-leveling of specimens (specimens are categorized into levels 1–6 according to their complexity) or wrong assignment by the pathologist on duty, which take time to correct, resulting in delayed sample delivery (43 cases, accounting for 25.9%). In 32 overdue cases (19.3%), sample delivery was delayed because the names on the specimens and examination sheets were unclear or did not match. In one case (0.6%), the sample was forgotten and remained undelivered until the error was noticed (Fig. 3C).

Results of monitoring the second subprocess are shown in Fig. 4. Reports were finished on the day of sample receipt (day 0) in 791 cases (3.9%; Fig. 4A); of these, 502 (63.5%) were frozen sections and 246 (31.1%) were delivered to the pathology laboratory right before closing time. Samples received just before closing time were processed, but receipt procedures were not carried out until the following work day when reports were issued. In 43 other cases (5.4%), the sample was categorized to an incorrect level or wrong assignment by the pathologist on duty; reports for these cases were issued immediately after the errors were rectified. Respectively, 44.8%, 37.7%, 9.4% and 2.3% of reports were issued on work days 1, 2, 3 and 4 after the day of sample receipt; there were 386 reports (1.9%) issued after 4 work days. Monthly, 0.4–3.6% of reports were overdue (Fig. 4B). The percentage of overdue reports was significantly higher before July (range, 1.2–3.6%) than after August (0.4–1.1%). Reports were overdue because of bone sample decalcification resulting in delay (161 cases, 41.7%), complex samples (143 cases, 37.1%), pathologists

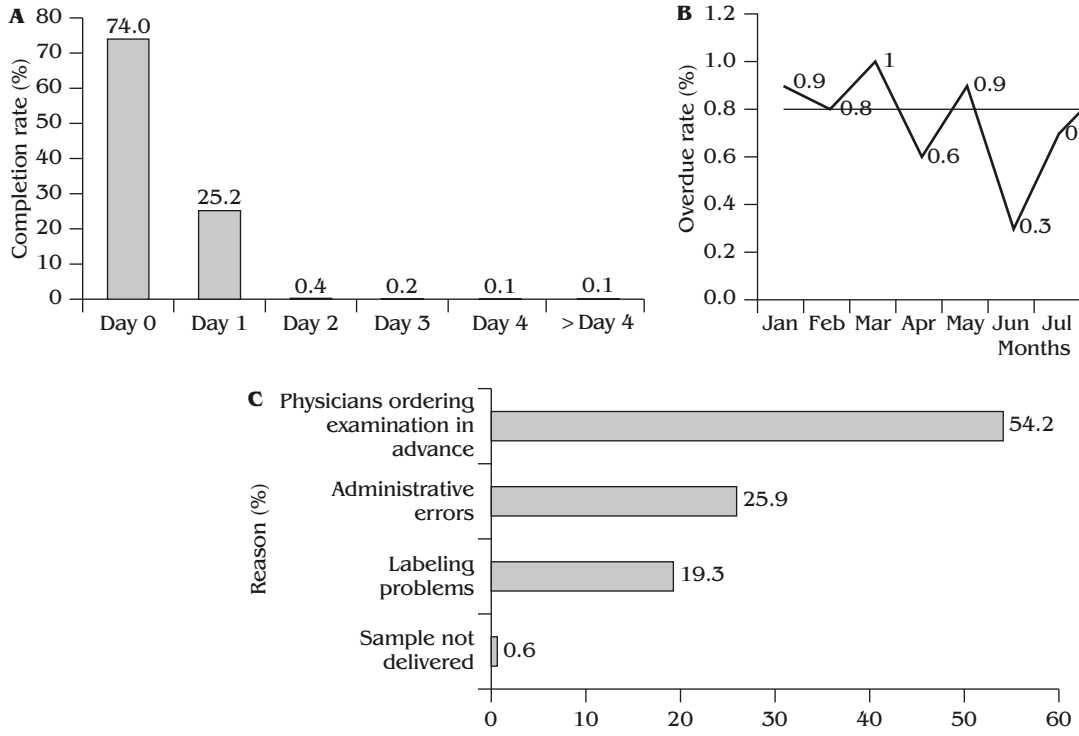

Fig. 3 — (A) Chart showing the sample delivery (by work days) from arranging a surgical pathology examination to receipt of the examination sheet and sample by the laboratory. (B) The control chart shows the monthly rate of late sample deliveries (—: the annual overdue rate was 0.8%). (C) Analysis of the reasons for late sample delivery.

themselves (54 cases, 13.9%), external pathology consultation (23 cases, 6.0%), renal biopsy sample sent to other hospitals for examination (4 cases, 1.0%), and unclear labeling of a pathology examination sheet and inability to contact the physician to check (1 case, 0.3%) (Fig. 4C).

There were 2239 positive reports (11.0% of all cases) that required automatic computer forwarding. Of these, 1888 (84.3%) involved cases of malignancies, 327 (14.6%) were follow-up cases, and 24 (1.1%) were cases of mycobacterial infection. In total, 2231 (99.6%) positive reports were forwarded automatically by computer and eight (0.4%) were not. Forwarding failed in five cases because the ordering physician was described on the examination sheet as the "physician on duty", and the computer could not decide which physician needed the report, and in three cases because the e-mail program had to be repaired and reports could not be sent until the following work day.

Of the 2234 reports successfully forwarded, 1868 (83.6%) were received and acknowledged by automated receipt within 120 hours, and 366 (16.4%) showed no response within 120 hours (the fourth subprocess; Fig. 5A). The percentage of positive reports received and acknowledged by e-mail receipt during each 24 hours up to 120 hours was 52.4%, 12.8%, 8.9%, 5.7% and 3.8%, respectively (Fig. 5B). The monthly rate of overdue responses was 2.8–31.9%, with January (27.3%) and February (31.9%) having the highest and December (2.8%) the lowest rates (Fig. 5C). The reasons for overdue replies were as follows: physicians did not check their e-mail (341 cases, 93.2%), pathology staff made operational e-mail errors (9 cases, 2.5%), physicians took a long vacation after arranging for an examination (8 cases, 2.2%), physicians were rotating with physicians from other hospitals, or were short-term or part-time, and so were not assigned an internal e-mail address (6 cases, 1.6%), and physicians left the hospital for outside training after arranging for the examination (2 cases, 0.5%) (Fig. 5D).

4. Discussion

Most of the literature on the quality assurance of surgical pathology workflow focuses on specific parts of the flow. We took the lead in using computers to monitor the surgical pathology workflow, which we divided into four subprocesses, and investigated the reasons for delays in each of the subprocesses and how the workflow might be further modified to improve efficiency. The results of this study may decrease medical errors (i.e., no follow-up of patients with positive reports because of poor communication

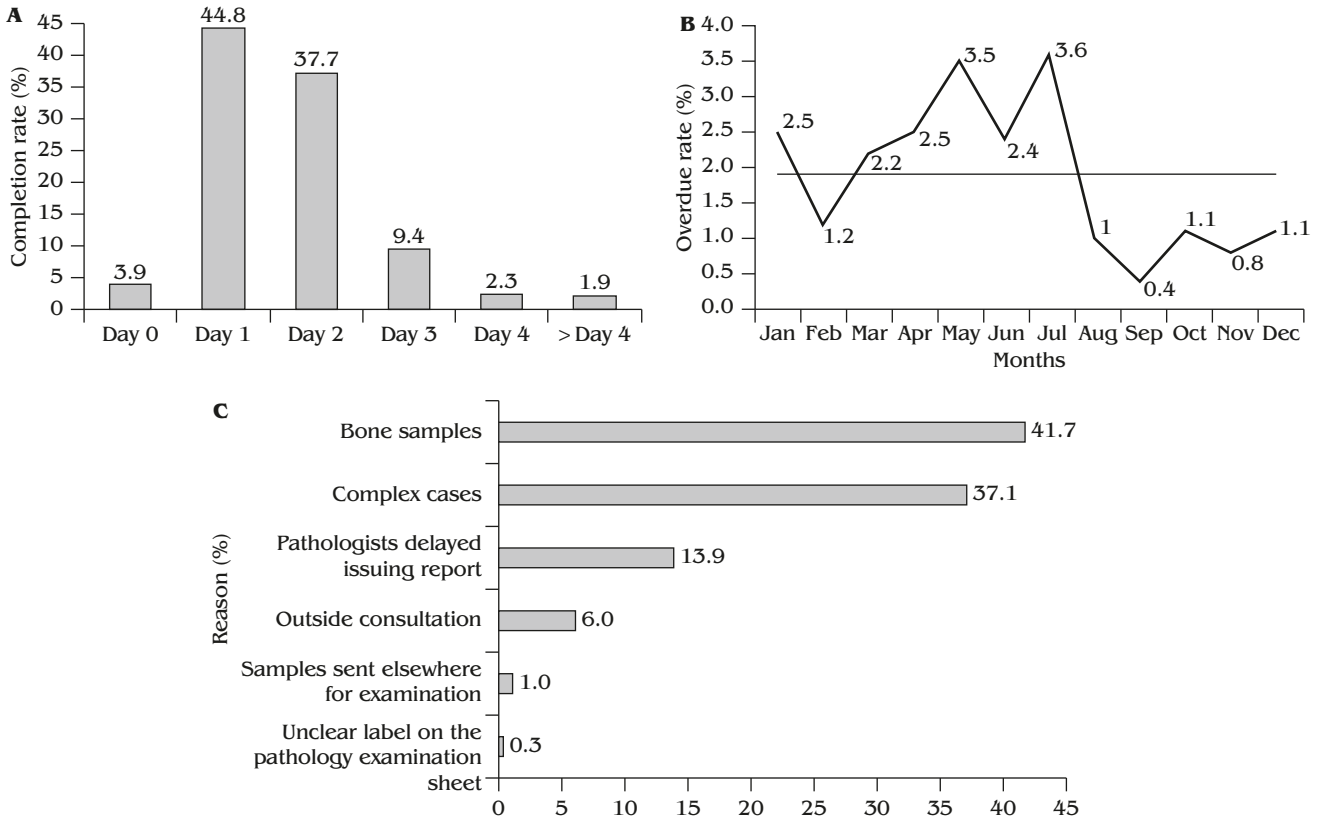

Fig. 4 — (A) Distribution of workflow completion by work days from receipt of the sample to issuance of the pathology report. (B) Monthly rate of overdue reporting (—: the annual overdue rate was 1.9%). (C) Analysis of the reasons for overdue reports.

between pathologists and clinicians) and medical disputes.

In the first subprocess (sample delivery), 99.2% of samples were delivered by the deadline. Sample delivery was late in most cases (52.4%) because the ordering physician scheduled sample collection for a later date. To correct this situation, the day of sample delivery should be changed from the day that the pathology examination is ordered to the day the sample is collected. To prevent delays in sample delivery caused by administrative errors and unclear labeling of the pathology examination sheet, continuing education of the medical team and communication can be improved. In addition, sample delivery times past the deadline can be shown on the computer. In extreme cases, the relevant sampling unit can be alerted and asked to carry out a review to improve the efficiency of sample delivery and decrease the chance of losing samples.

Our analysis of the rate of report completion did not discriminate between specimens that were simple biopsy or complex specimens. The rate of report completion within 1, 2 and 3 workdays was 48.7% (including 3.9% completed on the day of sample receipt), 86.4% and 95.8%, respectively (Fig. 4A). These rates were comparable to those reported by Novis et al [14] and Zarbo et al [16]. Our annual rate of overdue reporting was 1.9%; the monthly overdue rate was significantly higher before July than after August (Fig. 4B). Late reporting was mainly due to the fact that bone samples often had extremely long decalcification times. Therefore, we changed the method used for slicing calcified specimens. Previously, specimens were decalcified before slicing. To shorten decalcification time, a bone saw was used to cut the sample into thin slices and the decalcification solution was changed frequently. The other major reason for late reporting was delayed differential diagnosis because of prolonged, complex processing of samples (such as multiple immunohistochemical stains, special stains, fluorescent stains, and decalcification). Delayed reporting was also due to pathologist-related factors (e.g., being too busy, the need for extra time to look for mycobacterium, waiting for reviewed slides or pathology reports from other hospitals, missed reporting, re-sectioning of specimens due to poor quality of sample specimen), mailing of samples for external examination and pathology consultation, unclear information about the biopsy site on the examination sheet, and inability to reach physicians for correction or

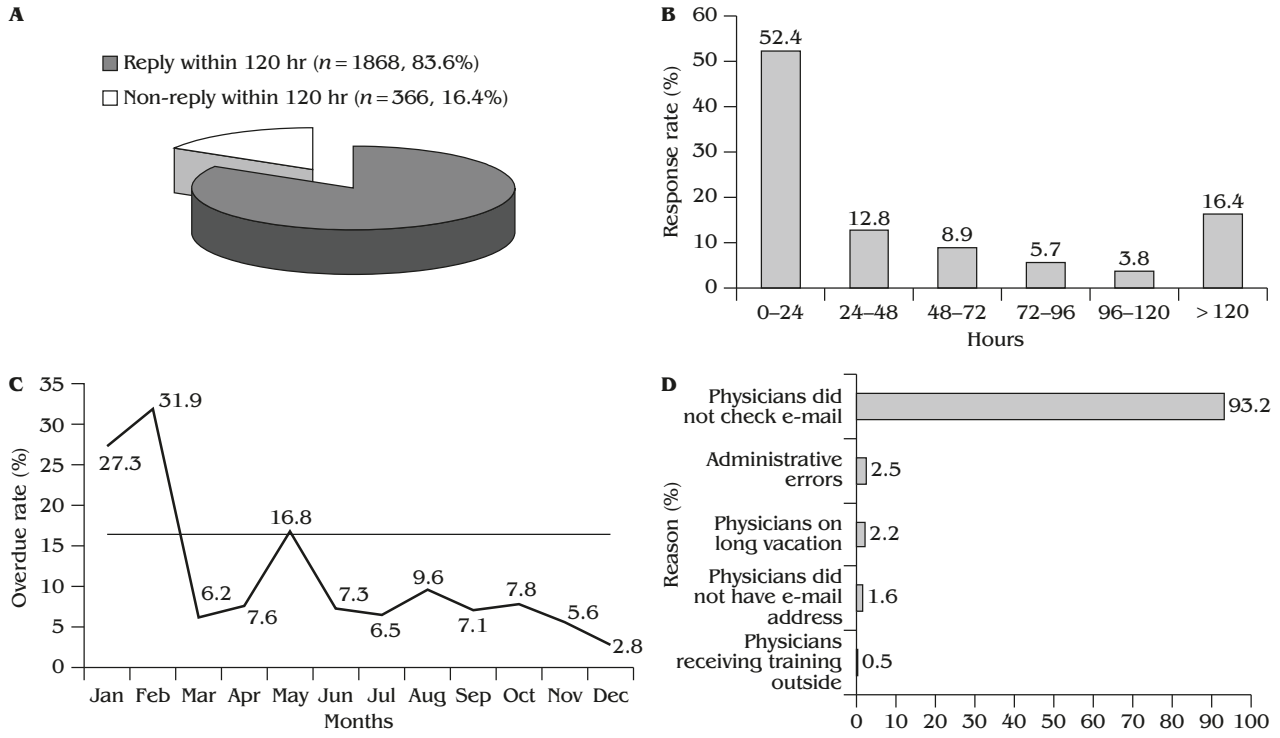

Fig. 5 — (A) Pie chart comparing rate (number) of acknowledgments with non-acknowledgments of positive reports by ordering physicians. (B) Bar graph showing the distribution of physicians' response rates on the basis of 24-hour intervals between receipt and response to positive reports. (C) The control chart shows the monthly rate of overdue acknowledgments of positive reports (—: the annual overdue rate was 16.4%). (D) Bar chart shows analysis of the reasons for failure to acknowledge positive reports.

clarification (Fig. 4C). Overall, the annual rate of overdue reporting (1.9%) was within the acceptable range.

Positive pathology reports dealing with malignancies and requirements for infection control notification or clinical follow-up may lead to disputes between pathologists and clinicians because of poor communication. Prior to this study, an extra hard copy of the positive pathology report was printed out and placed into the mailbox of the ordering physician. However, this method had its own shortcomings. We could not determine if and when the ordering physicians had received this positive report. In the event of a medical dispute related to the report, no determination could be made of who was responsible for the error. Therefore, we changed the workflow to that shown in Fig. 2. Of the 2239 positive reports requiring automatic computer forwarding, 99.6% were forwarded successfully. Of the eight failures, five were due to the program used by clinicians to order an examination. Failures of this kind were not repeated after the program was modified in July. The other three failures were due to crashes of the forwarding program; after program repairs the following day, message forwarding and normal workflow were resumed. Overall, the use of automatic computer forwarding for report notification is practical and feasible.

The advantages of using e-mail include speed, a paperless transfer, and the ability to automatically confirm receipt of the report by the ordering physician. Therefore, the record is clear, and responsibility in cases of disputed mailing of reports or notification can be established. Of the 2234 positive reports successfully forwarded by e-mail, 83.6% of clinicians acknowledged receipt within 120 hours (Fig. 5A), and 52.4% within the first 24 hours (Fig. 5B). This indicates that only half of clinicians checked their e-mail daily. Confirmation was not received within 120 hours in 16.4% of cases, with the highest rates being in January, February and May. The main reason for non-confirmation in January and February was physicians not checking their e-mail. This was because clinicians were not familiar with the new workflow guidelines despite receiving notification before their implementation, and also because of the 5-day Chinese lunar New Year vacation. Even if cases related to lunar New Year vacation were excluded, the overdue rate in February (26.6%) was still high. Therefore, to improve the response rate, we retrospectively notified physicians who failed to acknowledge receipt of positive reports more than twice per month via the local network inside the hospital and notified their office director, department director, and vice president of medical

practice. After administrative counseling and supervision in March, the failure-to-reply rate decreased immediately and significantly to below 10% (Fig. 5C). However, this rate returned to 16.8% in May because of a hospital evaluation which increased the work load of clinicians. The rate returned to below 10% after June. In general, for the whole year, the main reason (93.2% of cases) for not acknowledging receipt of reports was failure by physicians to check e-mail. Involving the hospital administration is an effective method to hasten the learning curve and decrease the failure-to-reply rate to below 10%. In addition, rotating physicians and part-time physicians must be given their own e-mail boxes. Finally, we hope that the 120-hour deadline can be reduced to speed up the workflow.

In conclusion, the use of computer-aided monitoring of surgical pathology workflow for quality assurance is feasible, although some issues still need to be improved.

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