Real-Time Intraoperative Consultation Reporting in the Electronic Health Record

An Innovative Method to Enhance Communication and Promote Patient Safety

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ABSTRACT

Objectives: *We sought to make pathologists' intraoperative consultation (IOC) results immediately available to the surgical team, other clinicians, and laboratory medicine colleagues to improve communication and decrease postanalytic errors.*

Methods: *We created an IOC report in our stand-alone laboratory information system that could be signed out prior to, and independent of, the final report, and transfer immediately to the electronic health record (EHR) as a preliminary diagnosis. We evaluated two metrics: preliminary (IOC) result review in the EHR by clinicians and postanalytic errors.*

Results: *We assessed 2,886 IOC orders from the first 22 months after implementation. Clinicians reviewed 1,956 (68%) of the IOC results while in preliminary status, including 1,399 (48%) within the first 24 hours. We evaluated 150 cases preimplementation and 300 cases postimplementation for discrepancies between the pathologist's IOC result and the IOC result recorded by the surgeon in the operative note. Discrepancies dropped from 12 of 150 preimplementation to 6 of 150 and 7 of 150 in postimplementation years 1 and 2. One of the 25 discrepancies had a major clinical impact.*

Conclusions: *Real-time reporting of IOC results to the EHR reliably transmits results immediately to clinical teams. This strategy reduces but does not eliminate postanalytic interpretive errors by clinical teams.*

Key Points

- We created an intraoperative consultation (IOC) report in our stand-alone laboratory information system that can be signed out by the pathologist prior to, and independent of, the final report and transferred immediately to the electronic health record.
- Sixty-eight percent of the IOC results were reviewed by the clinical team while in preliminary status (before the final pathology report was completed). Forty-eight percent were reviewed within the first 24 hours.
- The total number of discrepancies between the pathologist's IOC result and the surgeon's reported findings in the operative note dropped after implementation of the immediate reporting system.

Surgeons request frozen sections (intraoperative consultations [IOCs]) for a wide variety of indications. The pathologist may be required to provide a seemingly straightforward binary result (such as whether or not tumor is present at a margin) or a detailed result regarding tumor type that may determine which surgical procedure is required. Ideally, IOC results are given face to face, allowing for discussion of what information the surgeon absolutely requires to proceed with an immediate next step. This ideal is difficult to achieve when a pathologist is covering numerous operating rooms in a hospital and is not possible when using telepathology to cover multiple buildings in a large medical campus. When face-to-face communication is not possible, the pathologist generally provides the IOC via telephone, either directly or via other operating room staff. More sophisticated informatics-based solutions have also been developed to

reduce miscommunication and improve documentation.[1] In a pathologist's everyday practice, challenges and potential pitfalls in IOC communication are readily apparent and are amplified if the IOC result is not straightforward.[2]

At the University of Minnesota, we practice in an academic, tertiary care, multisite setting with a standalone laboratory information system (LIS) (v. 6.1.3, Sunquest CoPathPlus; Sunquest Information Systems) and an enterprise electronic health record (EHR) (Epic; Epic Systems). Prior to October 2016, there were three main pathways for incorporating IOC results in the EHR: (1) in the operative note, recorded as intraoperative findings by the surgeon or surgical house staff; (2) in the "intraoperative consultation" section of the completed final surgical pathology report; and (3) handwritten by the pathologist on the surgical pathology requisition form, which is then photocopied and transferred by surgical pathology staff to the clerical office and ultimately sent to health information management for scanning into the EHR. While the operative note (pathway 1) is typically recorded in the EHR in a timely fashion (on the day of the procedure), it may have incomplete or discrepant IOC results. The final surgical pathology report (pathway 2) may be delayed, especially for complex cases. Even for the swiftest final report, the IOC results must be transcribed from the handwritten result into CoPathPlus by a pathologists' assistant or pathology resident, which adds yet another opportunity for omission or error. A chart audit in our institution showed that the handwritten IOC diagnosis scanned into the EHR (pathway 3) was not clinically useful, as it took at least 3 days (range, 3-31 days) to be completed.

A prior study comparing pathologists' intraoperative diagnoses to operative notes showed that 20% of operative notes did not include the appropriate IOC results.[3] Other studies showed minor discrepancies between the IOC result recorded in operative notes compared with the pathologist's IOC result in 2.7% to 8.3% of cases.[4] A limited manual audit of our EHR in 2015 showed similar findings (unpublished data). We also had anecdotal evidence of incomplete IOC results or minor discrepancies in the IOC results reported in operative notes.

We identified this opportunity to improve our reporting and communication of IOC results as a means to reduce diagnostic errors and improve patient care. In its 2015 report, the Institute of Medicine's Committee on Diagnostic Error in Health Care noted that appropriate reporting and communication of test results are critical to reduce diagnostic errors. They emphasized collaboration between clinicians and diagnosticians (including pathologists), with timely exchange of information.[5]

Objective

We sought to document the IOC results in the EHR as a preliminary diagnosis, in real time, as a means of direct and immediate communication of the IOC results from the pathologist to the surgeon and the rest of the health care team.

We designed and implemented a procedure in CoPathPlus that would transfer IOC results directly to the EHR as a preliminary result. This would make the IOC available to the surgeon and surgical house staff intraoperatively and when composing their operative note. This new procedure would bypass the inefficient system that was previously in use, allowing for a preliminary diagnosis (with the pathologist's exact wording and electronic signature) in our LIS and in the EHR. We hypothesized that this would improve the surgeon's reporting of the IOC in the operative note, decreasing omissions and the less common minor discrepancies. While this new reporting system would require an extra step by the pathologist to enter and sign out an IOC procedure in CoPathPlus, it would eliminate several redundant steps from other pathology staff. Our pathologists agreed to take on this added task. The IOC results would also be immediately available to consulting clinicians and to colleagues in cytopathology, cytogenetics, and flow cytometry. This would allow colleagues to initiate correct processing of tissue for ancillary studies such as cytogenetics and thereby optimize those ancillary studies.

Two years after its implementation, we initiated an analysis of the efficacy of this quality improvement project. We sought to analyze the utility of real-time IOC result availability to the clinical team by identifying whether the surgeons did indeed review the IOC result in the EHR and the time when this review took place. In addition, we quantified postanalytic errors produced by discrepancies between the IOC result and the reported findings in the operative note and then compared them with those of the preimplementation era.

Materials and Methods

Information System Build and Configuration

The real-time IOC build involved creating a report (a "procedure") in CoPathPlus that could be signed out by the pathologist prior to, and independent of, the final report. This report would transmit to the EHR as a "preliminary" result. The "procedure" report has the ability to do this once an interface template is linked to it.

Two new text type fields were created that would be associated with the new procedure ("Preliminary

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Intraoperative Diagnosis" and "Preliminary Intraoperative Comment"). Indexing was enabled for both fields to facilitate natural language statistical queries.

A new procedure was then created called "Intraoperative Diagnosis" and filtered to the specimen classes being used with this new process. The new text type fields were added to the new procedure.

Five new report templates were created: an interface and final "hard copy" report template for the new IOC procedure, an interface and final "hard copy" report for the case (ie, "final") report, and a nested report template that would be embedded into the interface and final reports.

The nested template contained all the pertinent IOC data elements (diagnosis, comment, date ordered, date completed, date signed out, and the pathologist's signature). Although there were new text type fields, the procedure name ("Intraoperative Diagnosis") was configured to appear as a "header" for these fields. A computed expression was created that would default the name.

This nest also needed to appear at the bottom of the interface report once the final report was signed out. As a result, another computed expression was created within the nested template, which would suppress this nest from appearing at the top of the final case report if the procedure submitted was an IOC procedure; instead, it would appear at the bottom of the report.

In addition, "skip logic" was added to the nest object so that if no IOC procedure was associated with the case, no header (without corresponding diagnostic information) would appear erroneously.

Finally, a sixth template (yet another nested report), containing an expression to suppress the existing "Original Report Follows Addendum" header, was created to manage the nuances of the current report. Without this expression, the header would appear incorrectly if only an IOC procedure was created; it should only appear if a non-IOC procedure/addendum was created.

Once the procedure is signed out and transmits out of CoPathPlus, the integration engine, Rhapsody (Rhapsody Health), changes the code from "F" (final) to "P," so the procedure files into the EHR as a "preliminary" result. The engine does this based on the ***Preliminary*** header within the nested report.

If a report has more than one IOC procedure, only the most recent will appear when the preliminary result is viewed in the EHR. When an additional IOC procedure is signed out in CoPathPlus, the older IOC procedures are pushed to the "Results History" section of the preliminary result in the EHR. When the final report is signed out in CoPathPlus, it appears in the EHR as a "final" result and forces any preliminary results (IOC procedures) to file to "Results History."

The biggest challenge in the above build was the learning curve involved in creating the computed expression to prevent the IOC nested report from appearing at the top of the signed-out report.

Details of our CoPathPlus build configuration are included as Supplementary Figure 1 (all supplementary materials can be found at *American Journal of Clinical Pathology* online).

This study was conducted as a quality improvement and quality assurance project. As such it was not reviewed by the University of Minnesota Institutional Review Board per their policy (Investigator Manual HRP-103). This study was conducted in accordance with the Helsinki Declaration of 1975.

Evaluation Metrics

The solution build was completed and validated in the test environment in September 2016. Full implementation occurred in October 2016.

IOC Review Rate by Clinical Teams

We extracted approximately 22 months of patient encounters following the implementation (October 2016 to September 2018) from our LIS with associated frozen section charges (indicating that an IOC was performed on the case). We joined this list of encounters to our EHR database to extract corresponding audit information regarding the review of IOC result reports in the medical record as documented in the provider in-basket (the Epic result management system).We further analyzed the audit data to determine if the intraoperative results were reviewed in the medical record between the time the preliminary (IOC) result was issued and the final report was filed to the medical record. Evidence of result review was defined by an individual user completing any of the following actions in the in-basket: read, pend, done. Data analysis and visualization were performed in the Python programming language (version 3.6.6; Python Software Foundation) using the following libraries: Pandas (version 0.20.1), NumPy (version 1.12.1), and Matplotlib (version 2.0.2).

Impact on Postanalytic Errors

In total, 150 consecutive cases from each of the preimplementation, postimplementation year 1 (post-yr1), and postimplementation year 2 (post-yr2) periods were reviewed in CoPathPlus. The two postimplementation years were chosen (as opposed to auditing just 1 year) to

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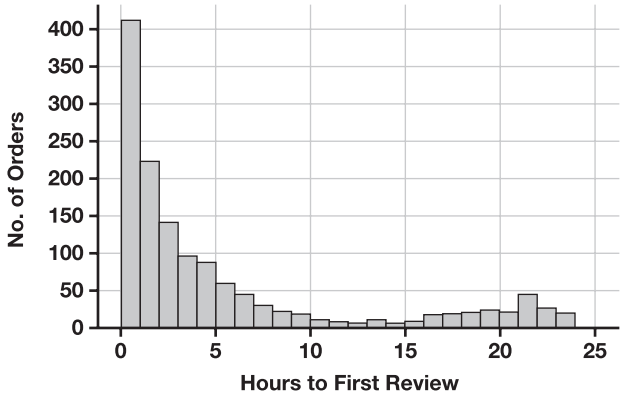

Figure 1 Number of hours to first review of results for intraoperative consultation (IOC) orders for reviews occurring in the first 24 hours following the transmittal of a preliminary IOC result to the medical record.

recognize any existent trend. The documented IOCs by the pathologist were compared with the operative note dictated by the surgeon or house staff in the EHR to assess concordance. Discrepancies were categorized based on the most likely underlying causation. Our goal was to identify the root cause of the discrepancies and whether the number of discrepancies in each category was differentially altered by the new reporting procedure. Only cases with completed operative notes that clearly documented the surgeon's interpretation of IOC were included in this study.

Results

IOC Review Rate by Clinical Providers

Our final data set included 2,886 orders in the 22 months postimplementation (post-yr1 and post-yr2). In total, 1,956 (68%) orders had a documented review time while in preliminary status. Of those 1,956 orders, 413 (14%) results were reviewed within the first hour following the preliminary (IOC) report being issued. A total of 1,399 (48%) were reviewed within the first 24 hours, and a total of 1,613 (55%) were reviewed within the first 48 hours. **Figure 1** shows the distribution of IOC orders reviewed in preliminary status (before the final result was issued) in the 24 hours after the preliminary result was made available in the medical record. A very small subset of orders (~2%) had no documented review time (either of preliminary or final result) at the time of result extraction. The median time between delivery of preliminary and final results for all cases undergoing IOC was 5 days 1 hour (25%, 2 days 9 hours; 75%, 7 days 3 hours).

Impact on Postanalytic Errors

As shown in **Table 1**, the total number of discrepancies between the IOC result and the reported findings in the operative note dropped from 12 of 150 in the preimplementation era to 6 and 7 of 150 in post-yr1 and post-yr2, respectively. Of the 25 total discrepancies, all but 1 had only minor clinical impact.

For each discrepancy, we analyzed the language used by the pathologist in the IOC and compared it with the language used by the surgeon in the operative note. One group of discrepancies was determined to be attributable to the pathologist's use of vague diagnostic terms ("pathologist's use of vague terminology" in Table 1). Several cases in this category were cartilaginous tumors where the pathologist rendered a diagnosis of cartilaginous tumor but did not commit to a benign or malignant diagnosis. In these cases, the surgeon recorded a diagnosis in the operative note that was more definitively benign or malignant than the IOC result. Other cases in this category were surgical margins, where the pathologist rendered a not completely benign or malignant diagnosis (results that included "atypia" or "atypical" and/or "cannot exclude" malignancy), some of which were hindered by the quality or amount of tissue available for frozen section. Again, in these cases, the surgeon tended to interpret these diagnoses as more definitively benign or malignant than the IOC result. In one case with multiple frozen sections, one margin was reported by the pathologist as "fragments of crushed blue cells, cannot rule out tumor, defer to permanents." In the operative note, the surgeon interpreted that frozen section result as "negative for malignancy" and did not resect additional tissue at that margin. The final diagnosis for that specimen was positive for malignancy, and ultimately, the patient required a repeat procedure to reexcise that margin. This is the one discrepancy that we identified between the pathologist's IOC and the surgeon's interpretation of the IOC that had major clinical impact. It occurred in post-yr1. The proportion of identified discrepancies in this group dropped from 50% preimplementation to 17% and 14% in post-yr1 and post-yr2, respectively.

Another group of discrepancies was felt to be due to miscommunication within the surgical team, with subsequent erroneous transcription of the result in the operative note ("Erroneous operative note" in Table 1). Three of the six cases in this category were total hysterectomy specimens from patients with preoperative diagnoses of "endometrial FIGO grade 1 endometrioid type adenocarcinoma, in a background of atypical hyperplasia" based on endometrial sampling. In these three cases, the pathologist rendered an IOC diagnosis of "endometrial FIGO

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Table 1
Discrepancies Between the Intraoperative Consultation (IOC) Result and the Reported Findings in the Operative Note

Cases	Pathologist's Use of Vague Terminology, No. (%)	Erroneous Operative Note, No. (%)	Operative Note With Additional Undocumented Findings, No. (%)	Total, No. (%)
Preimplementation (n = 150)	6 (50)	3 (25)	3 (25)	12 (100)
Post-yr1 (n = 150)	1 (17)	1 (17)	4 (67)	6 (100)
Post-yr2 (n = 150)	1 (14)	2 (19)	4 (57)	7 (100)
Total No.	8	6	11	25

Post-yr, postimplementation year.

grade 1 endometrioid adenocarcinoma," while the operative notes cited an IOC of "atypical hyperplasia." We postulate that the surgeon had the preoperative diagnosis at top of mind when dictating the operative note and mistakenly entered "atypical hyperplasia." These were still classified as minor discrepancies, because the cases with adenocarcinoma had minimal or no myometrial invasion, not necessitating procedures beyond the already performed hysterectomy and bilateral salpingo-oophorectomy. The proportion of discrepancies in this group showed a trend similar to the first group, dropping from 25% to 17% to 19%.

For the remaining discrepancies, we found terminology in the operative notes that seemed to originate from a pathologist (that would not have been used spontaneously by a surgeon) but was not included in the pathologist's IOC ("operative note with additional undocumented findings" in Table 1). For example, an IOC result of "spindle cell lesion, suspicious for fibromatosis" was recorded as "likely benign lipomatous tumor or perhaps low-grade fibromyxoid sarcoma" in the operative note. We suspect that "benign lipomatous tumor" and "low-grade fibromyxoid sarcoma" were raised by the pathologist in an intraoperative discussion with the surgeon regarding the differential diagnosis. The proportion of discrepancies in this group increased (from 25% to 67% to 57%). Although this third group of discrepancies accounted for a larger proportion of the discrepancies postimplementation, the absolute number of cases in this category was stable (three, four, and four cases for preimplementation, post-yr1, and post-yr2, respectively).

Discussion

In this article, we describe a practical solution aimed to help large departments with stand-alone LIS to report IOC in real time into their EHR. We also provide a follow-up assessment looking at two metrics: preliminary result review by clinicians in the EHR and impact on reducing postanalytic errors.

The new reporting system provided a simplified workflow. During regular surgical pathology hours, the IOC procedure is initiated in CoPathPlus by the accessioning staff, including the time the specimen is received. The pathologist reports the frozen section results to the surgeon (either in person or by telephone) and then uses the procedsure in CoPathPlus to enter the IOC results and to document the time the verbal report was provided. This system provides the pathologist's electronic signature as required by the College of American Pathologists' Lab Accreditation Program and documents the frozen section turnaround time. If several specimens for frozen section are received simultaneously, those results are listed in one IOC procedure. If one or more specimens for frozen section are received later for the same case, a new IOC procedure is initiated. Each IOC procedure (with one or more frozen section result[s]) is assigned to the covering pathologist. If additional specimens for frozen section are received after hours, the covering pathologist initiates a new IOC procedure in CoPathPlus. After the new process was implemented, we found that some clinicians and pathologists were unsure how to find the previous IOC results in the EHR for cases with multiple IOC results, as only the most recent IOC result appeared by default. We realized that we should have addressed this more directly during the training period. The only cases that did not have an IOC recorded in CoPathPlus and the EHR were those received after hours, without an accession number from earlier in the day. These were almost exclusively frozen sections on potential donor organs. For those cases, we default to handwritten documentation of the results (as was routinely done prior to implementation of this project and as outlined above). Our results show that the clinical team frequently reviews IOC results in the EHR ahead of the delivery of a final report, as occurred in 68% of cases. Fourteen percent of these first reviews occur in the first hour and approximately half in the first 24 hours after the preliminary report is issued. Real-time reporting of IOC to the EHR provides a reliable mechanism for

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delivering preliminary results to the clinical team and the potential to document their review. We had previously received ad hoc reports from individual surgeons of the utility of having IOC results available in the EHR. Given the resources required to develop and implement this functionality in our stand-alone LIS, we were encouraged by the widespread and timely review of IOC results in the EHR in the postimplementation period as confirmed by the EHR audit data.

A small subset of cases (~2%) did not contain a result review time (either preliminary or final result). There are methods for reviewing the result outside of the in-basket that would not directly trigger an audit log as captured in our extraction. It is likely that some of these results were otherwise reviewed or reviewed after the extraction was completed. Our observed rate of unacknowledged results is consistent with previously reported findings.[6]

Our analysis of IOC review times is subject to some limitations. Regarding in-basket preliminary result acknowledgment, we did not attempt to categorize the role of the reviewer. It is possible that the reviewer of the result may not have been the responsible provider, as many members of the team may receive a result for a case (a clinic nurse attached to a surgeon's in-basket, a surgical trainee [resident/fellow], or another provider involved in the care of the patient). Thus, we cannot document that the responsible surgeon was the individual to first review the result. Given the nature of team medicine, we chose to address the team as a functional unit in establishing result review, as the ordering, responsible, and reviewing care team member may differ for a given order, but they collectively contribute to the care of the patient. Second, there are additional ways to review results in the medical record (eg, opening a chart directly in the medical record and bypassing the in-basket) that would not trigger an audit trail in the data we extracted. Thus, some records that we define as unreviewed while in preliminary status may have been reviewed by a different method. Finally, another small subset of cases (~6%) had addendums or amendments to the final report. Because an amendment or addendum triggers a change in the time of the final report in the EHR, we could not determine whether the IOC was reviewed prior to the original (unamended or unaddended) final report. We included these cases in our total opportunity assessment (2,886 orders), but none were counted as being reviewed while in preliminary status. Thus, our assessment of the proportion of IOC results reviewed while in preliminary status is likely an underestimate.

FSLink-Frozen (Cerner DHT, Waltham, MA) section management software is a web application designed for real-time communication with the operating room (OR) for laboratories with a stand-alone LIS. It was developed in the pathology department in another tertiary care academic center to improve communication and patient safety.[1] The application manages all aspects of IOC, and like our solution, the surgical team is able to read the IOC on a screen in real time. It provides the added value of documentation by requiring a member of the surgical team to acknowledge receipt of the IOC result, using a touchscreen in the OR. However, it does not push the IOC to the EHR. By making the IOC an instant part of the patient's permanent record, our solution not only improves communication to the surgical team but also makes the IOC accessible to other providers caring for the patient and to other laboratory medicine staff for specimen processing and ancillary test triaging, prior to the release of the final report. Our solution tracks (in the LIS) the time the frozen section diagnosis was given. There is an optional "comments" section of the IOC, which may be used to document details of the interaction between the surgical and pathology teams if desired.

Prior authors have shown that the current standard of communicating IOC results is less than perfect and have called for improvements to reduce postanalytic errors.[3] Our results show that real-time IOC reporting in the EHR does in fact reduce but does not fully eliminate miscommunication. Both the surgeon and the pathologist are working under multiple constraints during frozen sections, making concise and complete exchange of information in these critical moments a challenge. Our analysis of the pathologist's language used in the IOC and the surgeon's language used to record the IOC result in operative notes allowed us to identify instances of miscommunication and to classify those instances into three groups. The first group was attributable to the pathologist's use of vague diagnostic terms, whether in an attempt to communicate uncertainty or for another reason. In this study, real-time IOC reporting drastically reduced this error from 6 in 150 cases to just 1 in 150 cases for the first 2 years after implementation. The challenge of communicating uncertainty by pathologists has been well documented in the surgical pathology literature.[7,8] Our study shows that real-time reporting in the EHR is a logical and practical strategy to address this challenge, at least for IOCs. The second group of discrepancies was simply erroneous transcription of the results in the operative note that could not be attributed to a communication error made by the pathologist. Our proposed model of reporting reduced this error type slightly, from 3 in 150 to 1 and 2 per 150 cases in years 1 and 2 after implementation, respectively. The third group included pathology terminology in the operative note that was different from what was documented in the IOC and seemed to be related to

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informal, back-and-forth intraoperative discussion between the pathologist and surgeon but not documented in the pathologist's IOC. This type of discrepancy persisted and slightly increased (from 3 in 150 cases to 4 in 150 cases for the each of the first 2 years after implementation). Part of pathologists' role is to make themselves available to clarify and discuss diagnoses (including differential diagnoses) with their clinical colleagues.[9] In the intraoperative setting, there is exceptional pressure for the pathologist to communicate clearly and address the surgeon's specific queries while documenting the pathologist-surgeon interaction accurately. The examples uncovered in this study show how undocumented back-and-forth intraoperative discussion can produce unintended errors. With the reduction in the discrepancies in the 2 previous groups by real-time IOC reporting, discrepancies in the third group became the most common type. When this phenomenon was discussed among pathologists, they were not particularly aware this was happening. The risk of "overexplaining" diagnoses, even in a final pathology report, has been highlighted by others, showing that a final diagnosis may be perfectly clear but made cloudy by a pathologist's extended comment.[7] This study reiterates this lesson to concisely and effectively communicate IOCs and avoid "overexplaining," to decrease diagnostic errors and promote patient safety.

Conclusion

Real-time reporting of intraoperative results to the EHR provides a robust and reliable method for transmitting results to clinical teams. These results are widely read in the immediate postoperative period and may contribute to a reduction in postanalytic interpretive errors by clinical teams.

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