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Implementing a Software Solution Across Multiple Ultrasound Vendors to Auto-fill Reports with Measurement Values

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A B S T R A C T

Reliable transmission of ultrasound measurements into radiology reports is fraught with potential sources of error. In a conventional workflow, measurements are either written by hand on worksheets and/or dictated from worksheets or the images themselves into the radiology report. Valuable physician time is spent dictating, checking, and editing these values and this process is error-prone. Our approach was to use a transfer-software application to auto-populate measurements, with a goal of achieving >90% utilization rate by both technologists and radiologists. Implementation involved creating measurement fields for each measurement on each ultrasound unit of our multisite academic department. These fields were then mapped in both the transfer-software and the dictation software, to set up a 1:1:1 correspondence for each field. As a result, each measurement acquired by the technologist would automatically populate the radiology report within the dictation software. We created and mapped 128 fields for 39 exam templates. After implementation, technologist utilization rate was 86%-96% and overall radiologist utilization rate was 92%-93%. Radiology resident utilization rate was highest, at 95%-96%. We provide a guide for implementation and lessons learned.

Description of the Problem

Radiology ultrasound reports include multiple measurements both of normal anatomy and also of pathology detected on the exam. The conventional workflow for reporting ultrasound measurements is tedious, time intensive, and has the potential for introduction of errors at multiple steps. In one recent study, reporting errors related to measurements were found in 6%-28% of ultrasound reports.[1] In the conventional workflow, structures are first sonographically measured by the sonographer who then completes a written or electronic worksheet, which is transmitted to the radiologist. If the sonographer does not complete a worksheet, the radiologist searches through the individual images to identify the required measurements. The radiologist then types or dictates these measurements into the radiology report.

We believed that automatic, direct measurement transfer from the ultrasound console to the radiology reporting system would present a more reliable method of incorporating measurements into the final radiology report. Such a strategy has previously been described for ultrasound units from a single vendor using an ultrasound PACS intermediary.[2] Our implementation would need to accommodate ultrasound units from 2 different vendors (LogiqE9 from GE Healthcare, Milwaukee, WI; and iU22 from Philips Medical Systems, Andover, MA) to start and potentially others in the future, as we do not have an exclusive vendor. Furthermore, since at our institution there is no dedicated ultrasound PACS, our data transmission workflow would need to be different than the previously reported implementation. Our goal was to implement a system where measurements acquired on any ultrasound unit are automatically transmitted into the final radiology report generated in the reporting software. We set a goal for 90% utilization rate by both technologists and radiologists.

Institutional Approach Employed to Address the Problem

The radiology department at our multisite academic medical center operates 21 diagnostic ultrasound units. Radiology reports are generated by voice dictation using Powerscribe 360 (PS360, Nuance, Burlington, MA). Modlink (Hyland Software, Westlake, OH) software is a vendor-neutral package which accepts DICOM-SR and HL7 messages from modalities, converts them as necessary, and transmits them to the dictation software. The financial practicality of this software was recently shown in a paper on cost analysis[1] (although this was only reported after our implementation). In that report, based on their modeling of radiologist and sonographer productivity, they project that over a 5-year period there would be a savings of

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$824,548. Information technology (IT), ultrasound technologist, and radiologist champions were identified who would lead and assist with the implementation.

Ultrasound exams typically performed in the emergency department (such as right upper quadrant, complete abdomen, renal/bladder, scrotum, thyroid, pelvic, and pregnancy) were targeted for automatic measurement transfer. For each exam, a list of measurements was made which would need to be represented as fields on each ultrasound unit, within Modlink and within PS360. Some "factory fields" such as liver length were used. Other fields were created de novo as "custom fields" to suit our workflow. For example, although there are factory fields for each pelvic measurement, separate transabdominal and transvaginal fields were created for each measurement such that each is routed to the correct portion of the report (i.e., either the transabdominal section or the transvaginal section). Custom fields were piloted on one unit from each vendor before scaling up.

Standardized structured reporting dictation templates for radiology ultrasound exams had already been implemented at our institution.[3] We updated each template within PS360 to include custom merge-fields for ultrasound measurements, into which the measurements were auto-transmitted via Modlink. For some exams, a reporting instruction screen was created within PS360 so that radiologists could choose between different reporting templates or opt out of using auto-transmitted measurements, if necessary (Fig 1). For example, when a right upper quadrant ultrasound exam was launched in the dictation software, there were choices for an auto-filling template with the spleen or one without the spleen (as depending on cirrhotic appearance of the liver, the spleen may or may not be imaged at our institution). Once an appropriate template was chosen, all standardized measurements would auto-fill in the report (Fig 2).

We used test exams to obtain measurements for each field. These test exams were then launched in the dictation software to confirm that data for each field were being transmitted accurately, with appropriate units, and with the correct number of decimal places. In total, we created and mapped 128 fields for 39 exam templates. Following implementation, all ultrasound technologists were trained to perform studies using the institutional measurement fields, which is a requirement for measurement transmission. This involved teaching appropriate field selection using a touch screen or a mouse click prior to measurement acquisition at the ultrasound console.

Description of the Outcomes of the Institutional Practice or Change in Practice

Auto-populating measurements in ultrasound reports have been well received by our faculty. We received positive feedback that this initiative both reduces dictation time and allows radiologists to focus on the images rather than transcribing numbers. To measure actual utilization rates, we reviewed 338 consecutive pelvic, scrotal, and second trimester US exams at the main hospital campus, over a 2-month time period (January and February 2018). These exams were chosen because they represent high, medium, and low frequency exams for which auto-filling templates were implemented. Included were 222 pelvic ultrasound exams, 88 scrotal ultrasound exams, and 28 second trimester pregnancy ultrasound exams. We determined that after implementation and training, technologists used the field packages in 93%, 86%, and 96% of cases, respectively. Cases were signed by 34 attendings (who signed 1-42 cases, mean = 9.9 cases). Of the 338 cases analyzed, 42 cases (12%) were not dictated using a structured report (32 cases by 1 attending, and 5 cases each by 2 other attendings). Among reports in which the radiologist used a structured reporting template (n = 296), 92%, 93%, and 92% of these were dictated using templates with auto-filling measurements, respectively. When a resident predictated the report with an attending, usage increased to 95%, 95%, and 96%, respectively.

Training the technologists and radiologists to be vigilant for errors was an important component of the implementation. Technical failure and human error are inevitable and these would need to be identified and corrected as they would occur. Therefore, despite the system working in the vast majority of cases, measurements would still need to be reviewed. This is one example which occasionally occurred. If the common bile duct is measured in error as 14 mm, the technologist may realize this and delete the inaccurate image with

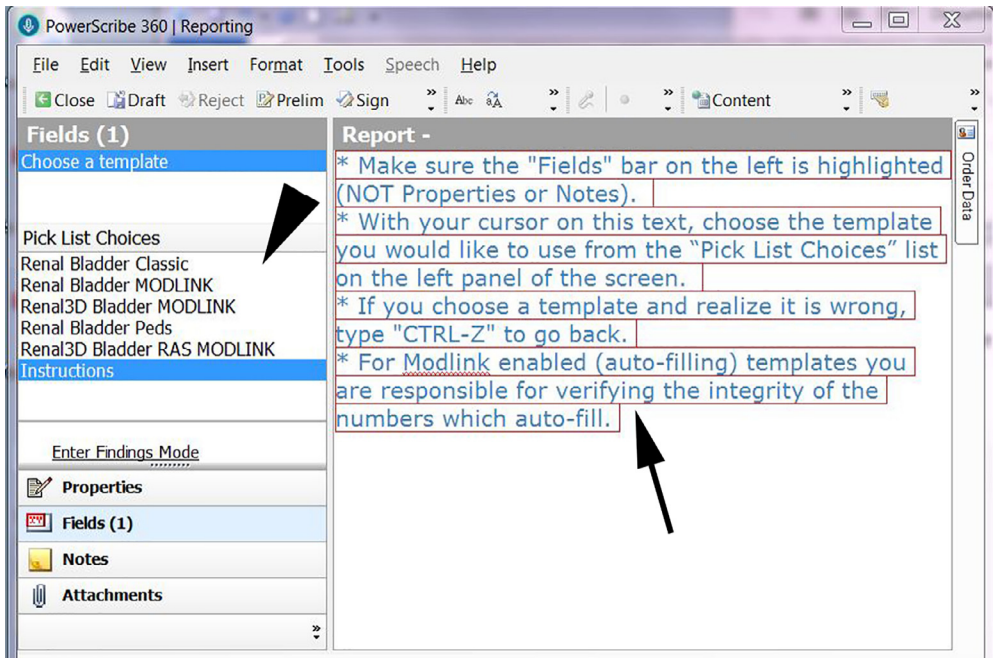
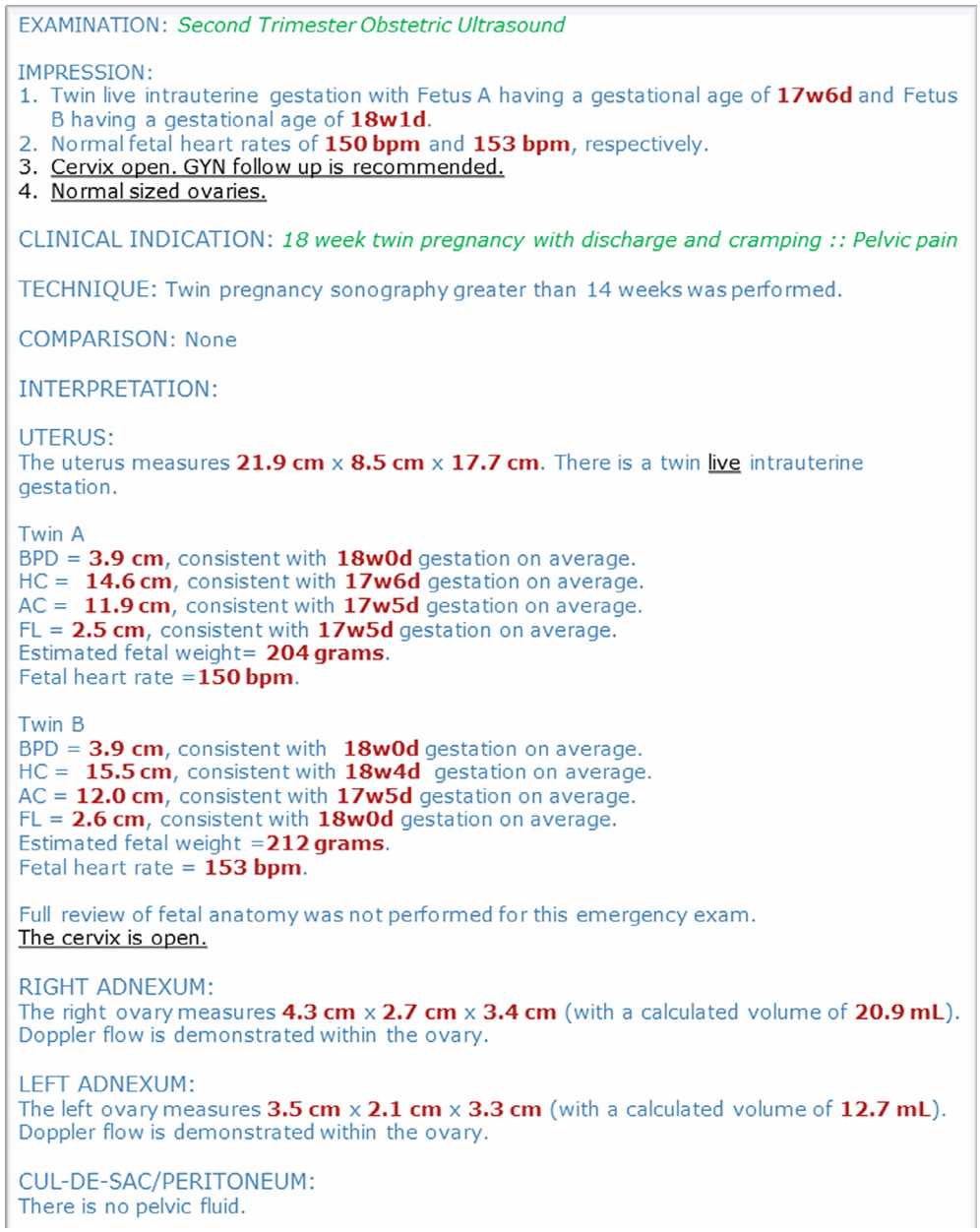


FIG 1. Sample instructions screen within the PS360 dictation software. When the exam is launched in the dictation system, a page opens which provides a quick set of instructions (arrow). In the panel at the left (arrowhead), there is a list of appropriate template options. Different templates can easily be chosen for this renal and bladder ultrasound exam with a double-click. "Classic" indicates a nonauto-filling template. "MODLINK" indicates a template which auto-fills with measurements. Renal3D indicates that 3 dimensional measurements are provided for each kidney rather than just its length. RAS is a structured template for a renal artery stenosis exam.



EXAMINATION: *Second Trimester Obstetric Ultrasound*

IMPRESSION:
1. Twin live intrauterine gestation with Fetus A having a gestational age of **17w6d** and Fetus B having a gestational age of **18w1d**.
2. Normal fetal heart rates of **150 bpm** and **153 bpm**, respectively.
3. Cervix open. GYN follow up is recommended.
4. Normal sized ovaries.

CLINICAL INDICATION: *18 week twin pregnancy with discharge and cramping :: Pelvic pain*

TECHNIQUE: Twin pregnancy sonography greater than 14 weeks was performed.

COMPARISON: None

INTERPRETATION:

UTERUS:
The uterus measures **21.9 cm** x **8.5 cm** x **17.7 cm**. There is a twin live intrauterine gestation.

Twin A
BPD = **3.9 cm**, consistent with **18w0d** gestation on average.
HC = **14.6 cm**, consistent with **17w6d** gestation on average.
AC = **11.9 cm**, consistent with **17w5d** gestation on average.
FL = **2.5 cm**, consistent with **17w5d** gestation on average.
Estimated fetal weight= **204 grams**.
Fetal heart rate =**150 bpm**.

Twin B
BPD = **3.9 cm**, consistent with **18w0d** gestation on average.
HC = **15.5 cm**, consistent with **18w4d** gestation on average.
AC = **12.0 cm**, consistent with **17w5d** gestation on average.
FL = **2.6 cm**, consistent with **18w0d** gestation on average.
Estimated fetal weight =**212 grams**.
Fetal heart rate = **153 bpm**.

Full review of fetal anatomy was not performed for this emergency exam.
The cervix is open.

RIGHT ADNEXUM:
The right ovary measures **4.3 cm** x **2.7 cm** x **3.4 cm** (with a calculated volume of **20.9 mL**).
Doppler flow is demonstrated within the ovary.

LEFT ADNEXUM:
The left ovary measures **3.5 cm** x **2.1 cm** x **3.3 cm** (with a calculated volume of **12.7 mL**).
Doppler flow is demonstrated within the ovary.

CUL-DE-SAC/PERITONEUM:
There is no pelvic fluid.

FIG 2. Sample auto-filling report for a twin intrauterine gestation ultrasound exam. Green (italic) text indicates information populating from the Radiology information system (RIS). Red (bold) text indicates measurements which are populated using Modlink's measurement auto-filling functionality. Blue (standard) text indicates text which is present as part of the standard reporting template. Black (underlined) text indicates text entered by the radiologist. (Color version of figure is available online.)

that measurement. However, the measurement will still be stored by the ultrasound unit, unless it is also deleted from the ultrasound unit's memory data tables. When the technologist re-measures the common bile duct accurately as 4 mm, the auto-filling system, depending on the configuration, may transmit the largest value obtained (14 mm) or an average of the 2 values (9 mm), thereby leading to a report with a wrong measurement. This is one example of why it is always essential to review all measurements. An important corollary to this is that when no measurement is transmitted, the radiologist must determine whether this was due to a systems error, or was it because the technologist did not see the item and therefore could not measure it. Depending on the cause, the radiologist would enter the value manually or report that the item was not identified sonographically.

Discussion and Future Directions

We learned valuable lessons during the planning and implementation phases. User feedback after implementation was also instructive, and much was learned from actual day to day usage following the rollout. We share these lessons and several cautions below:

Lessons Learned:

- *Leadership:* Required for success are designated champion information technologists, ultrasound technologists, and radiologists, identified at project outset in order to guide the process.
- *Project scope:* The scope of the project must be defined with the various stakeholders. Certain exams, such as routine emergency department exams, are more conducive to measurement auto-

filling; the anatomy being examined is constant and the measurements required for reporting are consistent. For more complex studies, for example, liver transplant Doppler ultrasound, in which the exam is more difficult for the technologist to perform and the report is more complex for the radiologist to dictate, there will be a greater need for workflow modification and training. These exams will be more challenging to successfully incorporate into a consistent auto-filling workflow in a large institution. Ultimately, we decided not to implement an auto-filling template for transplant exams due to the extensive training requirement.

- *Gold-standard configuration:* Troubleshooting of measurement fields should be performed on a single pilot ultrasound unit at first rather than having different versions implemented on different units. If different changes are made concurrently on different units, a "gold-standard" configuration will not be able to be maintained.
- *Air-scans:* Mapping and testing of fields should be performed in bulk using test exams with "air scans"[2] rather than waiting for clinical exams to be performed and using those studies for mapping. (An air scan refers to a test exam where multiple measurements are made on a single blank image [or a few blank images] with no patient image captured, rather than scanning a patient to measure real anatomic structures one at a time.)
- *Vendor buy-in:* Assistance from both the ultrasound equipment and the software vendor is necessary to handle technical problems. Unfortunately, this technology is not at a level of maturity which would allow simple plug-and-play functionality.
- *Custom fields:* The ability to configure custom fields is essential to allow for reporting of all measurement values expected by the referring physicians at your institution, some of which may not be available in the factory-field list.
- *Measurement transmission:* Having measurement data transmitted to the reporting software automatically at the conclusion of the exam is essential. Requiring an additional step to manually send the measurements will lead to occasional lack of data transmission.
- *Template variation availability:* Even for a single exam name, there will be the inevitable need for different templates. Therefore, there must be a thoughtful consideration of the expected variations and construction of template options which will be appropriate for each scenario.
- *Template launch:* The reporting templates which auto-fill with these measurements should be easily accessible by the radiologist. In our experience, having a limited list of appropriate templates for each exam is much more easily used by the radiologist compared to choosing a template from a long list of all templates.

Cautions:

- *Error correction is a continuous process:* There must be a workflow for reporting the inevitable problems that are encountered and errors must be corrected in a timely manner. Those charged with correcting errors must be responsive to the reporters and encourage this feedback in order to ensure accurate reporting. Integrated methods of feedback reporting have been described in the literature as being effective for improving exam quality feedback.[4,5]

Conclusions

Auto-filling of ultrasound measurements streamlines ultrasound reporting, and allows the radiologist to focus on the imaging findings rather than the required documentation of numerical data. Following implementation, use of these templates by radiologists exceeded 90% of ultrasound exams. With proper planning prior to implementation (including identifying a leadership team and defining the scope of the project), customizing the system to institutional preferences, and troubleshooting during the process, such a system can be effectively implemented to streamline ultrasound measurement reporting.

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