



Short Communication

A pathology order interface based on the transmission of texts obtained from pathology requisitions and just-in-time construction of HL7 messages

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ABSTRACT

Background: A pathology order interface using Health Level 7 standards (HL7) generally has an HL7 client program that gathers information from the clinical electronic medical record system, packages the information in the form of HL7 message, and sends the message using secure communication protocols to an HL7 interface engine located on the pathology side. We describe an alternative approach that transmits the texts obtained from requisitions, with subsequent just-in-time construction of HL7 messages.

Materials and methods: The order interface is between a dermatology clinic EMR and pathology information system. A text acquisition and processing program runs in the background in desktop computers in dermatology clinic so that a copy of pathology requisition text is obtained each time when the clinic prints a pathology requisition. Discrete elements of the data are extracted from this text, prepended to the text and saved on a shared drive within the dermatology office intranet. This text file is then transferred to pathology intranet using secure File Transfer Protocol (sFTP). Once received, an HL7 message construction program extracts the discrete data elements to construct an HL7 message. The HL7 message is then forwarded to an HL7 interface engine and entered into the pathology information system as an order.

Results: Using an actual case as an example, the content and format of the information flowing through different steps of the interface are demonstrated.

Conclusions: The construction of such an interface does not involve the clinic EMR vendor, thus avoiding its associated cost and potential delay. This interface has advantages over our other order interfaces constructed using the conventional approach in that it does not require a change of order process and it avoids duplicate orders.

Introduction

Health Level 7 (HL7) formed in 1987 provides standards for communication of health information between different systems, thus serving as common standards for interface implementation.^{1,2}

The implementation of an HL7 interface generally involves the EMR vendor. Depending upon the HL7 version supported, the vendor writes program(s) on the sending side to place the discrete information in the appropriate location within the HL7 message, and then send the message securely to the receiving side.²⁻⁴ All of our previously constructed interfaces follow this convention.

Our experience has been that most EMR vendors, including vendors of cloud-based EMR, charge a fee to set up an interface and it will typically take several months to set up. The dermatology clinic that we serve uses a cloud-based information system. In addition, the dermatology clinic outsources its IT work, thus lacking onsite expertise for writing programs that could send HL7 messages. This prompted us to consider if there were

ways that we could accomplish constructing an order interface solely relying on the technical capabilities within the pathology group.

Utilizing the text on pathology requisition was an intuitive choice for us, since it contained all the information required for accessioning a case. As a result, we have developed an order interface based on the text on the requisition.

Materials and methods

A typical computer workstation used in dermatology office is an Intel NUC desktop PC (Intel, Santa Clara, CA) with Intel(R) Core(TM) i5-10210U CPU @ 1.60 GHz and 8.0 GB random-access memory. The dermatology office information system is EMA 6.2.4 (Modernizing Medicine, Inc, Boca Raton, FL). The pathology information system is PowerPath 10.0.0.19 (Sunquest Information Systems, Tucson, AZ), with Advanced Material Processing (AMP module). The backend database management system for PowerPath is Microsoft SQL server.

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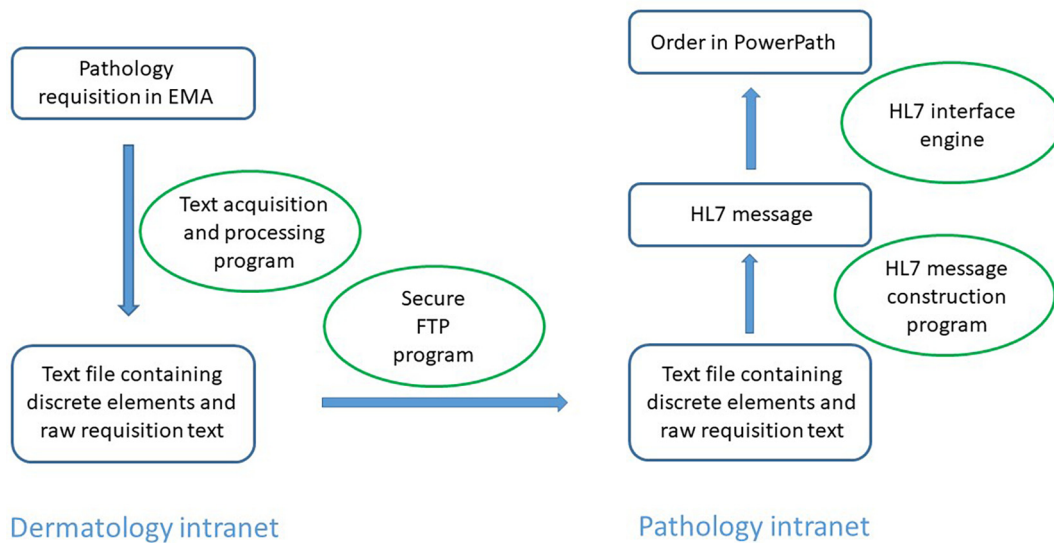


Fig. 1. Diagram of information flow of the order interface. The blue round-angled boxes denote information at different stage. The green ovals denote programs that render the flow/conversion of the information.

Fig. 1 shows the information flow of the order interface. The order information resides in the pathology requisition in EMA. Its text is acquired, processed, and saved to a text file in the dermatology intranet; transmitted securely to the pathology intranet; constructed into an HL7 message; and entered into PowerPath as an order. These 4 steps are performed by a text acquisition and processing program, a .NET program for sending securely, an HL7 message construction program, and an HL7 interface engine, respectively.

The pre-existing pathology order process for the clinic is as follows: when specimen(s) are collected on a patient, relevant information is entered into EMA. The clinic staff then navigates to a page on EMA that displays requisition in a PDF format. Clicking the printer icon on that page brings up a dialog box for the staff to pick which printer to print the paper requisition. The specimens are then submitted with the accompanying requisition.

AutoHotkey (www.autohotkey.com, accessed July 21, 2022) scripting language is used to write the text acquisition and processing program. The functions of the program are to obtain a copy of requisition text and extract discrete data elements from the text for each case. The program uses AutoHotkey’s “ImageSearch” function to determine if a click is performed on the printer icon or somewhere else. If a click is performed on the printer icon, the program will select the text in the PDF requisition and copy it onto the clipboard. The program then obtains the unstructured text from the clipboard, extracts discrete data elements from the text, concatenates the elements into a pipe-delimited string, and saves both the extracted discrete data elements and unstructured original text in a single text file on a shared drive within the dermatology clinic intranet. The file name includes the order number of the particular pathology requisition.

While this is happening, the text in the PDF requisition is highlighted, serving as a cue that the interface program is in action. After about a 2-s delay, the usual printer dialog box will appear, allowing the medical assistants to proceed with the printing of the paper requisition.

Some extractions are relatively simple. Simple extractions of discrete data element rely on certain fixed text tags in the raw text before (front tag) and after (back tag) the text of interest. For example, “Order Number” is frequently followed by “Bill type” (Fig. 2). Therefore, order number can be extracted using following program lines:

```
pos1 := InStr(req_text, "Order Number:")
pos2 := InStr(req_text, "Bill Type", 1, pos1)
if (pos2 < 1) {
    pos2 := InStr(req_text, "r`n", 1, pos1)
}
```

```
order_num := Trim(SubStr(req_text, pos1 + 14, pos2-pos1-14), OmitChars := " `t`r`n.")
```

It is noteworthy that on rare occasions, there are requisitions with order number line ending with the actual order number, i.e., without “Bill Type” as the back tag, then carriage return and linefeed “`r`n” is used as a back tag (the conditional in the above program takes care of these rare occasions).

Other extractions are more nuanced. For example, the extraction of specimen list and procedures is a substantially more complicated process. We use “Accession # Test #” and “Electronically Signed” as front and back tags (see Fig. 2) to isolate out the specimen and procedure information segment. Then, all the carriage returns and linefeeds are replaced by single spaces, making this segment a single line of string. Regular expression is needed for extraction. An example of regular expressions used to extract the specimen description is as follows:

```
specimen := Trim(RegexReplace(specimen_procedures, "[A-Z]\. (.*) (Snip Biopsy|Biopsy by Shave Method and Destruction|Biopsy by Shave Method|Mohs Surgery with Preop Frozen Section Biopsy|Excision|Mohs Surgery with Debulk Specimen and Permanent Final Margin|Mohs Surgery with Debulk Specimen|Shave removal|Nail Avulsion)", "$1"), OmitChars := " `t`r`n.")
```

After the extractions, additional processing is performed before packaging the extracted data into a chain of discrete data elements. Some elements, such as patient’s name and address, require linking several extracted elements by the symbol “”. Specimen list requires the capping of a specimen code “SKIN-EXC-W” and linking different specimens with symbol “~”. Procedures require simplifying and grouping (in multiple specimen cases). These extracted and processed elements are then concatenated by a pipe symbol “|” to form a single line to prepend to the raw text.

For the first 200–300 consecutive cases, each interface text file was reviewed to compare the extracted data elements with the unstructured raw text to ensure the accuracy of the data extraction. Whenever an extraction error was noted, the text acquisition and processing program was modified so that it would handle the similar situation correctly. In addition, all 3 dermatopathologists continue to pay attention to the specimen description, clinical information, and procedures in each report from this clinic. Whenever anything unusual is noted, the scanned-in pdf requisition would be reviewed.

A Microsoft .NET program using a secure File Transfer Protocol (FTP) client is installed on a desktop PC within the dermatology clinic intranet. At 1-min intervals, this client program transfers the above text files on a shared drive within the dermatology intranet to the pathology sFTP server. TLS 256 bits encryption is used.

```

XXX_order_144514 - Notepad
File Edit Format View Help
72350|20430357|PATIENT^JOHN^X|Male|01/01/1960|123 ANY RD^^ANY TOWN^XX^01234|
321-1234|Provider FNP-C^Jane|144514|07/19/2022 11:44 AM EDT|
SKIN-EXC-W}right lateral zygoma~SKIN-EXC-W}left superior preauricular cheek|
A. Keratotic patch. DDX: Actinic Keratosis vs. other.
B. Keratotic papule. DDX: Squamous Cell Carcinoma vs. other.|#1-2 Shave biopsy|

Path Req - July 19, 2022
Order Number: 144514 Bill Type: Third-Party Bill
MRN:
72350
PATIENT INFORMATION
LAST NAME
PATIENT
FIRST NAME
JOHN
M.I.
X
SSN DATE OF BIRTH
01/01/1960
SEX
Male

PATH REQUISITION
Location Procedure Clinical Information ICD Accession # Test #
A. right lateral zygoma Biopsy by Shave Method
H and E
Morphology: Keratotic patch
DDX: Actinic Keratosis vs. other D48.5
144514-A
B. left superior
preauricular cheek
Biopsy by Shave Method
H and E
Morphology: Keratotic papule
DDX: Squamous Cell Carcinoma vs. other D48.5
144514-B
Electronically Signed By: Jane Provider, FNP-C, 07/19/2022 11:44 AM EDT

```

Fig. 2. An example of the content of a requisition text file with pipe-delimited data. The text displayed is a rendition of a real patient data file with all the patient identifying information altered to protect the patient privacy. The name of the provider is also altered. The specimen description, clinical information, and procedures are unaltered.

Once the file is within the pathology intranet, an HL7 message construction program written in Visual Basic constructs a complete HL7 message from the file. The program reads in the first line containing 13 pipe-delimited data elements. Some elements require additional processing in order for the element to be acceptable by PowerPath. For examples, “Female” is changed to “F” and “Male” is changed to “M”; “Sr” or “Jr” in the last name is stripped; and a provider code unique to each provider is concatenated with the provider name. These elements are then built into separate and distinct segments. The message header segment (MSH) contains control information such as the message type, a control ID, and the date/time of the message. Next is the patient identification segment (PID) which contains the patient name, medical record number, address, phone number, sex, date of birth, and billing number. A patient visit segment (PV1) contains the provider’s ID and name as well as the case visit number. The observation request segment (OBR) has the case type, date of service, order number, specimen codes, and specimen descriptions. Last are the observation result segments (OBX) which contain clinical and procedure information. All of these segments are assembled to form a complete HL7 message.

The constructed HL7 message is then forwarded to an HL7 interface engine to be processed and sent to PowerPath as an order. The HL7 engine

was developed in-house to allow full control of internal interfaces and access to internal servers and systems. This HL7 engine utilizes a scripting engine to allow for creation or modification of HL7 files from client data by accessing crosswalk look-up tables and/or database tables uniquely per interface if required.

For each specimen, both the requisition and the specimen label affixed to the specimen container have a QR code. It contains information including patient’s name, order number, specimen description, and so on. Although strictly speaking not part of the interface, 2 simple programs were written to utilize the information on the QR code to further automate the accessioning of the case. A Visual Basic program puts the text information of the QR code on the clipboard once the code is scanned; an AutoHotkey program uses that information to locate the particular order associated with the specimen and brings up a new case window with the order information populated into the case.

Results

Fig. 2 shows an example of the content of a text file saved on the shared drive within the dermatology clinic intranet. The file contains the pipe-delimited discrete elements that have been extracted from the unstructured

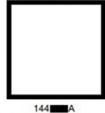

PATH REQUISITION					
Location	Procedure	Clinical Information	ICD	Accession #	Test #
A. right lateral zygoma	Biopsy by Shave Method H and E	Morphology: Keratotic patch DDX: Actinic Keratosis vs. other	D48.5		
B. left superior preauricular cheek	Biopsy by Shave Method H and E	Morphology: Keratotic papule DDX: Squamous Cell Carcinoma vs. other	D48.5		

Fig. 3. Image of the portion of requisition containing the information on specimen, procedure, and clinical information. The QR codes on the right most column are replaced by empty squares to protect the patient privacy. The last 3 digits of the order numbers beneath the QR codes are also erased.

requisition raw text as the first line. In the actual file, this is a single line. It is broken into several lines in the figure for display purposes. The rest of the file is the unstructured raw text from the requisition. Only selected portions of the raw text is displayed in Fig. 2; the actual raw text is longer.

Fig. 3 shows the portion of PDF requisition containing information on specimens. As one can see in Fig. 2, when text is copied from the PDF requisition (Fig. 3), certain irregularity is introduced. For specimen A, the location (specimen description) and procedure is in a single line. For specimen B, they are located in 3 different lines. To remove this irregularity, as described in Materials and Methods, all the carriage returns and linefeeds are replaced by single spaces to form a single line: “A. right lateral zygoma Biopsy by Shave Method Morphology: Keratotic patch DDX: Actinic Keratosis vs. other D48.5 144514-A B. left superior preauricular cheek Biopsy by Shave Method Morphology: Keratotic papule DDX: Squamous Cell Carcinoma vs. other D48.5 144514-B”. The number of occurrences of the word “Morphology” is used to determine the number of specimens. Specimen, clinical information, and procedure is parsed out from the above single line to yield 3 discrete data elements: “|SKIN-EXC-W}right lateral zygoma~SKIN-EXC-W}left superior preauricular cheek|A. Keratotic patch. DDX: Actinic Keratosis vs. other. B. Keratotic papule. DDX: Squamous Cell Carcinoma vs. other.|#1-2 Shave biopsy|”.

The elements in the pipe-delimited line are medical record number, EMA ID, patient’s full name, sex, date of birth, address, home phone number, provider name, order number, procedure date, specimen list, clinical information, and procedures, respectively (Fig. 2).

After this file has been transmitted to pathology, the discrete data elements from the first line are extracted to construct a complete HL7 message. Fig. 4 shows the HL7 message thus constructed. This message is then sent to an HL7 interface engine for processing and forwarding to PowerPath as a new order.

After the specimens of the patient are received, an accessioner scans the QR code for specimen A, either on the specimen bottle or on the requisition (Fig. 3). This brings up a new case window in PowerPath with the required

information from the order populated in the case. With or without adjusting the number of cassettes to print, the accessioner can then press a key to confirm the creation of a new case.

After the case is accessioned and when a pathologists assistant is grossing in the case, clinical information is automatically pulled into the preliminary pathology report, obviating the need for dictating the clinical information and avoiding potential voice recognition errors. The clinical information for the above example case is as follows:

- A. Keratotic patch. DDX: Actinic Keratosis vs. other.
- B. Keratotic papule. DDX: Squamous Cell Carcinoma vs. other.
- Post-op dx:
- Procedure: #1-2 Shave biopsy

Discussions

We devised this way of building an order interface mainly due to the intent to see if we could build an order interface solely relying on the expertise within the pathology group without involving the vendor of the clinic EMR. As a result, the interface has been constructed without incurring the cost of engaging the vendor of the clinic EMR. After the interface is in operation, we realize that it has some advantages over our other conventionally built interfaces.

The first advantage is that the clinic staff does not need to learn a new process of placing the pathology orders. The staff only needs to ensure that the text acquisition and processing program runs in the background. AutoHotkey’s capability to enable a program to know if a click is on the printer icon or somewhere else on the screen makes it possible to have the clinic staff maintain their existing pathology order process. The program only causes a 2-s delay in the requisition printing process. This not only does not increase the burden on the clinic staff, but also guarantees that the orders are placed correctly. In comparison, our interfaces constructed using the conventional approach require the change of the order process from the existing paper-based approach. As a result, there are

```

XXX_order_144514 - Notepad
File Edit Format View Help
MSH|^~\}|PITTIS||20220719114810||ORM^O01|20220719114810|P|2.3|
PID|1|72350|Patient^John^X||1950723|M||123 ANY RD^ANY TOWN^XX^01234||321-1234|||||20430357|
PV1|1|||||13197^Provider FNP-C^Jane|||||||144514|
ORC|NW|144514|
OBR|1|144514||S_1^DC SURG|||202207191144|||||SKIN-EXC-W}Right lateral zygoma~SKIN-EXC-W}Left
superior preauricular cheek|
OBX||ST|DC_CLINICAL_INFORMATION||A. Keratotic patch. DDX: Actinic Keratosis vs. other.
B. Keratotic papule. DDX: Squamous Cell Carcinoma vs. other.|
OBX||ST|DC_PROCEDURE||#1-2 Shave biopsy|
Ln 9, Col 41 100% Macintosh (CR) UTF-8
    
```

Fig. 4. Example of a constructed HL7 message. The text displayed is a rendition of a real HL7 message file constructed from text in Fig. 2, with all the patient identifying information altered to protect the patient privacy. The name of the provider is also altered. The specimen description, clinical information, and procedures are unaltered. Both the OBR segment and first OBX segment are single lines in the message but wrapped around in the figure for better display.

certain orders that have the information placed in the wrong places, most frequently being misplacing the clinical information in the specimen description.

The second advantage is that there are no duplicated electronic orders. If a provider or a clinic staff realizes that certain information on the requisition needs to be changed, one can simply make the changes within EMA and reprint the paper requisition. This process generates a new electronic order with the same order number, resulting in the new order replacing the old order. In most of our conventionally constructed order interfaces, a new order with different order number would have been generated. The old order would need to be reconciled and manually deleted from the order list in PowerPath.

Although it is not part of the interface, the construction of the interface and the availability of QR code on the specimen label and requisition have enabled us to write programs that automate the accessioning process. In fact, this is the most accessioner-friendly order interface we have built because the added automation programs make the accessioning a scan-driven process, significantly reducing the number of keystrokes and mouse clicks in accessioning. In comparison, our other order interfaces require an accessioner to key in either patient's name or order number in order to pull up the electronic order from the list of orders.

This approach of building order interfaces has its limitations too. An obvious one is that it can be constructed only when the pathology order process in the clinic EMR involves entering the order information electronically, with subsequent printing of requisition using that information. If the existing order process for the clinic is entirely paper-based without printable requisitions generated from internal electronic content, this approach will not work.

Extracting discrete data elements from the unstructured texts of the requisitions is a challenging part of the programming and also potentially a fragile point of the interface. It took retrospective analysis of roughly 100 requisitions to write the extraction portion of the program so that the program will extract the data correctly most of the time. After experiencing additional 200–300 requisitions prospectively, with additional programming to handle the newly encountered rare variations of the texts, the program is able to handle all the variabilities of the requisitions and consistently extract the data correctly. After that, the program has experienced additional 1000 requisitions and extracted the data correctly in all of these cases.

Three authors' divergent and complementary strengths have made the completion of this project possible. The first author's (JY) domain

knowledge in dermatopathology and experience in Windows automation (using AutoHotkey) and text processing (multiple programming languages) enabled him to efficiently write the text acquisition and processing program. He signs out 40% of the cases from this dermatology clinic, giving him the opportunity to directly monitor the correctness of data extraction on a continual basis. He has familiarized himself with the accessioning process by accessioning approximately 100 cases from this clinic, enabling him to make the subsequent accessioning of these cases a scan-driven process. The second author's (DH) expertise in programming on the Microsoft .NET platform and in cybersecurity well equipped him to write the program to securely transfer the interface files from dermatology clinic intranet to the pathology sFTP server. The third author (BE) is a dedicated interface programmer whose sole responsibility is writing and maintaining all of our interfaces, perfectly suited for constructing the complete HL7 messages from the discrete data elements in the interface text files.

In summary, the order interface we have constructed using an AutoHotkey program to acquire and process requisition texts, with subsequent just-in-time construction of HL7 messages using Visual Basic .NET, not only avoids the cost of involving the vendor of clinic EMR but also has some distinctive operational advantages. Its underlying principle may potentially be adoptable by other pathology departments/groups for similar situations, particularly when a pathology department/group has both the general programming capability and interface programming capability.

Conflict of Interest

None of the authors has any conflict of interest.

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