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Technical Note

Web-based synoptic reporting for cancer checklists

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Abstract

Background: The surgical pathology report remains the primary source for information to guide the treatment of patients with cancer. Failure to report critical elements in a cancer report is an increasing problem in pathology because of the heightened complexity of these reports and number of elements that are important for patient care. The American College of Surgeons Commission on Cancer (ACS-CoC) in concert with the College of American Pathologists (CAP) developed checklists that contain all of the scientifically validated data elements that are to be reported for cancer specimens. Most institutions do not as of yet have pathology information systems in which CAP checklists are embedded into the laboratory information system (LIS). Entering the required elements often requires extensive text editing, secretarial support and deletion of extraneous elements that can be an arduous task.

Materials and Methods: We sought to develop a web-based system that was available throughout the workstations in our department and was capable of generating synoptic reports based on the CAP guidelines. The program was written in a manner that allowed automatic generation of the web-based checklists through a parsing algorithm.

Results: Multiple web-based synoptic report generators have been developed to encompass required elements of cancer synoptic reports as required by the ACS-CoC/ CAP. In addition, utilizing the same program, report generators for certain molecular tests (KRAS mutation) and FISH studies (UroVysion™) have also been developed. The output of these reports can be cut-and-pasted into any text-based anatomic pathology LIS. In addition, the elements can be compiled in a database.

Conclusions: We describe a simple method to automate the development of web-based synoptic reports that can be entered into the anatomic pathology LIS and database.

Key words: Cancer registry, cancer report template, cancer checklists, synoptic reporting, tumor reporting

INTRODUCTION

Surgical pathology cancer reports are meant to report all pathologic information relevant to the treatment of the patient, such as type of tumor, status of margins and submitted lymph nodes. However, the amount of information required has grown dramatically and as a result, essential elements are often lacking in reports,[1] and there is significant variation in reporting terminology and presentation of the data among different pathologists.[2,3]

In an attempt to remedy this situation, proposals were

presented to develop a synoptic style of reporting for cancer specimens to increase efficiency and ensure uniform reports that contained all pertinent data.[4] The American College of Surgeons Commission on Cancer (ACS-CoC) seized on the importance of synoptic reporting and mandated that pathology reports at the roughly 1,400 ACS-CoC accredited cancer hospitals contain all of the scientifically validated data elements. To comply with this mandate the College of American Pathologists (CAP) has developed site-specific cancer reporting checklists that are continuously updated and available at the CAP website.[5]

The use of the CAP checklists for cancer reporting has significantly reduced omissions and improved consistency.[6-11] These are currently provided in either a Microsoft® Word® based document (.doc) or a portable document file (.pdf) format. Both of these formats require significant intermediate steps in order to generate a final synoptic report. For instance, if the checklists are simply cut-and-pasted from the word document a significant number of unused choices must be deleted. If the checklists are printed out and the elements are dictated, significant work must be performed by transcriptionists in order to render the final report. The least desirable option would be printing out a copy of the checklist, noting the required elements by checking the appropriate boxes or filling in the data field, and then submitting that to the patient's chart where it may or may not be scanned into the patient's clinical record.

We sought to develop a web-based system for generating cancer reports that required minimal text entry and editing and could be entered into the anatomic pathology LIS via a simple cut-and-paste operation. Furthermore, our goal was to create a system that would allow for the automated generation of web-based reports for each of the site-specific cancer checklists since the current number of these checklists is quite large (currently 64 CAP checklists exist). An additional benefit to such a system is that it provides an easy mechanism to allow entry of the pathologic elements into a searchable database.

METHODS

Our institution currently employs synoptic cancer-based reporting for a number of anatomic specimen sites based on the CAP checklists. These Microsoft Word®-based documents were modified to include descriptors of the needed web elements, including radio buttons for mutually exclusive choices (for example, the type of tumor could be selected from a given list); checkboxes for elements that might contain multiple choices (for example, location of positive margins); and text box entry for free entry items such as tumor size [Figure 1]. An

```
[Prostate]

Specimen: RADIO{}
Prostate, radical prostatectomy
Prostate, robot-assisted radical prostatectomy

Tumor: RADIO{}
Prostatic adenocarcinoma
[Other: ] BOX

Gleason score: RADIO{}
GLEASON
Prior hormonal therapy, not Gleason-graded

CHECKBOX
Tertiary pattern BOX{} %

Maximal tumor nodule diameter measured on one level (cm): BOX{}

Multifocal tumor: RADIO{}
Y
N

Location of dominant tumor(s): CHECKBOXLIST{}
R Apex
L Apex
R Mid
L Mid
R Base
L Base
R Postero-lateral (neurovascular bundle)
L Postero-lateral (neurovascular bundle)
R Anterior
L Anterior
R Posterior
L Posterior

Percent of prostate gland involved by tumor: BOX{} %

Extraprostatic extension: RADIO{}
Absent
Present- Focal, [specify site, mm] BOX
Present- Established, [specific site] BOX

Margins: RADIO{}
Benign glands at surgical margin (capsular incision)
Margins negative for invasive carcinoma
Margins positive for invasive carcinoma: CHECKBOXLIST
Apical
Bladder neck
Anterior
Lateral
Postero-lateral (neurovascular bundle)
Posterior
Margin focally involved by invasive carcinoma, extent (mm): BOX
Margin extensively involved by invasive carcinoma, extent (mm): BOX
END

Angiolymphatic invasion: RADIO{}
Absent
Present
Indeterminate

Seminal vesicle invasion: RADIO{}
Absent
Present
Indeterminate

Pathologic Staging (pTNM) 7th edition AJCC
Primary Tumor (pT): RADIO{}
pT2a: Organ confined, Unilateral, involving one-half of 1 lobe or less
pT2b: Organ confined, Unilateral, involving more than one-half of 1 lobe
pT2c: Organ confined, Bilateral disease
pT2x: Organ confined, but extends to margin more than focally
pT3: Extraprostatic extension
pT3a: Extraprostatic extension
pT3b: Seminal vesicle invasion
pT4: Invasion of rectum, levator muscles or pelvic wall

Regional Lymph Nodes (pN): RADIO{}
pNX: Cannot be assessed
pN0: No regional lymph node metastasis ( 0 / BOX )
pN1: Metastasis in regional lymph node or nodes ( BOX / BOX )
```

Figure 1:Template. This template file is read by the parsing program. Descriptors of web elements have been added for parsing purposes

```
function parse(LINE)
  if LINE contains "CHECKBOXLIST"
    parse remainder of LINE                          //Obtain name for display and database
    SQL_CREATE_COMMAND += title of group
    HTML_FILE += create checkbox list
    loop until "END" or empty line: read next LINE   //Read in choices
      HTML_FILE += create checkbox with...           //Add code, text is added by next parse
      PHP_FILE += if this box is checked...          //Add code, text is added by next parse
      SQL_SAVE_COMMAND += if this box is checked, save...  //Add code, text is added by next parse
      parse next LINE                                //Recursively finds nested checklists and boxes
  ...
  else if LINE contains "BOX"
      SQL_CREATE_COMMAND += title of box
      HTML_FILE += text box
      PHP_FILE += display entry in box
      SQL_SAVE_COMMAND += save entry to database
      parse remainder of LINE
  ...
  else
      HTML_FILE += LINE
      PHP_FILE += display LINE
      SQL_SAVE_COMMAND += LINE
      parse next LINE
```

Figure 2: Pseudocode for parsing algorithm. As the program parses the file, it generates an SQL command for creation of the database table, an HTML form for entry, and a PHP file to read the HTML form entry, output a report, and prepare an SQL database entry

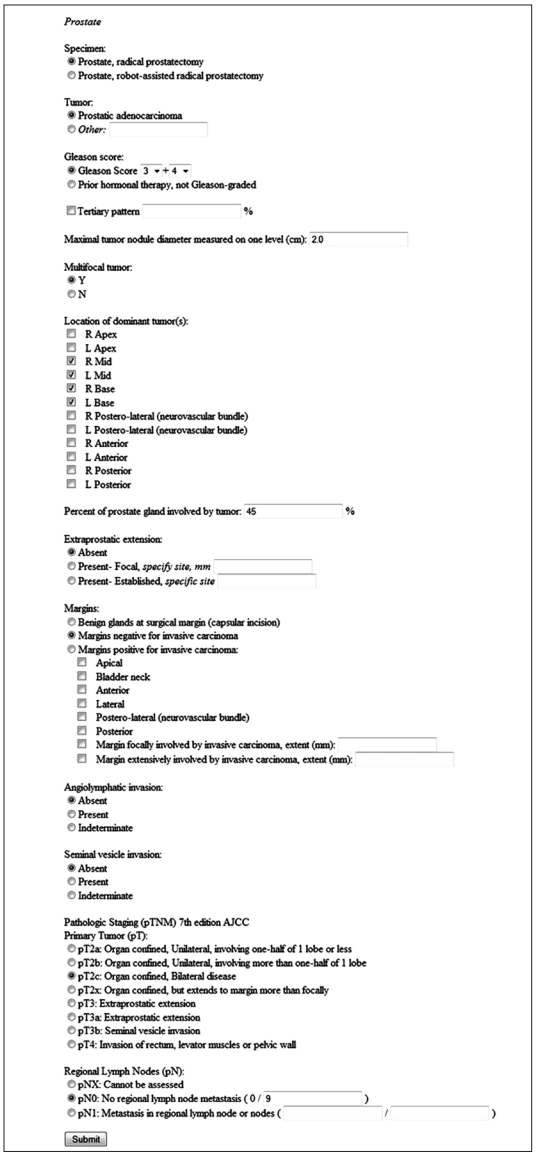
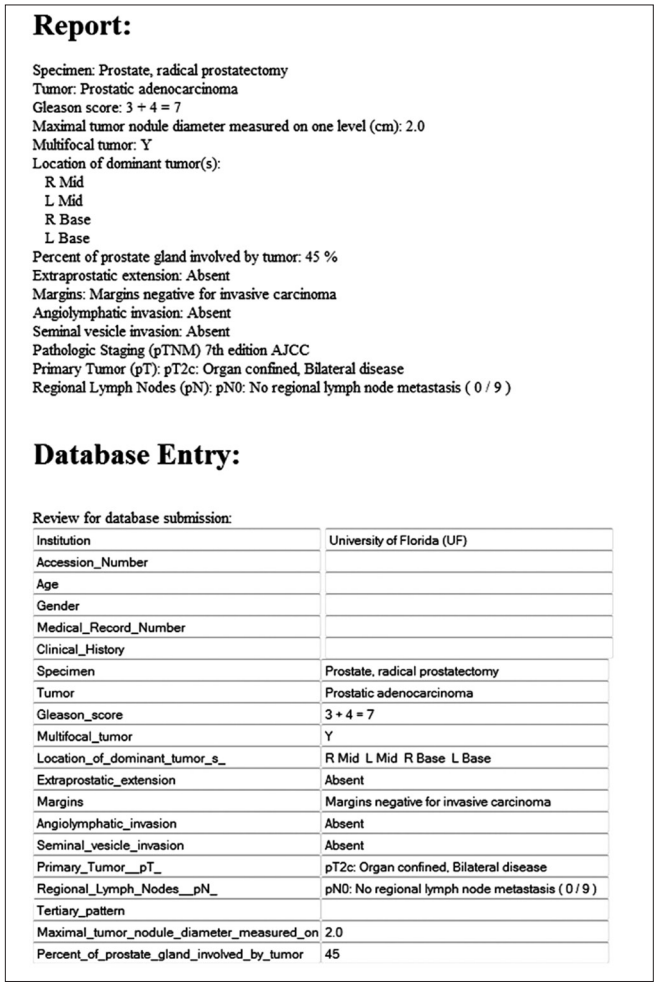


Figure 3: Web form for entry of specimen data. The web form that was generated from the template makes use of radio buttons, checklists, and text boxes to gather data from the user



Report:

Specimen: Prostate, radical prostatectomy
Tumor: Prostatic adenocarcinoma
Gleason score: 3 + 4 = 7
Maximal tumor nodule diameter measured on one level (cm): 2.0
Multifocal tumor: Y
Location of dominant tumor(s):
R Mid
L Mid
R Base
L Base
Percent of prostate gland involved by tumor: 45 %
Extraprostatic extension: Absent
Margins: Margins negative for invasive carcinoma
Angiolymphatic invasion: Absent
Seminal vesicle invasion: Absent
Pathologic Staging (pTNM) 7th edition AJCC
Primary Tumor (pT): pT2c: Organ confined, Bilateral disease
Regional Lymph Nodes (pN): pN0: No regional lymph node metastasis (0 / 9)

Database Entry:

Review for database submission:

Institution	University of Florida (UF)
Accession_Number	
Age	
Gender	
Medical_Record_Number	
Clinical_History	
Specimen	Prostate, radical prostatectomy
Tumor	Prostatic adenocarcinoma
Gleason_score	3 + 4 = 7
Multifocal_tumor	Y
Location_of_dominant_tumor_s_	R Mid L Mid R Base L Base
Extraprostatic_extension	Absent
Margins	Margins negative for invasive carcinoma
Angiolymphatic_invasion	Absent
Seminal_vesicle_invasion	Absent
Primary_Tumor__pT_	pT2c: Organ confined, Bilateral disease
Regional_Lymph_Nodes__pN_	pN0: No regional lymph node metastasis (0 / 9)
Tertiary_pattern	
Maximal_tumor_nodule_diameter_measured_on	2.0
Percent_of_prostate_gland_involved_by_tumor	45

Figure 4: Results of form submission. A report is generated based on the form entries, and a tentative database entry is shown for user confirmation

algorithm was written in the PHP Hypertext Processor language [Figure 2] to parse the documents for these descriptors and generate a Structured Query Language (SQL) command to create the database, an HTML form for entry, [Figure 3] and a PHP file to generate the report and fill the database with the case information after review by the user [Figure 4].

In brief, the algorithm parses the text template [Figure 1] line by line and looks for the key descriptors. If "radio" or "checkboxlist" is found, the lines following it are parsed to obtain the choices. The parse function is run on each line in order to recursively deal with nested lists, and it will appropriately increase indentation with each tier. If "box" is found, a text box is inserted. Text in square brackets is considered a comment to appear in the web form for the pathologist but not in the final report. Curly brackets after a descriptor (radio{}, checkboxlist{}, box{}) indicate that a database entry should be made for this item. The database name is either the text within the brackets or, if empty, the text to the left of the descriptor. The database entry is made in the PHP file

Figure 5: Database search page with autocompletion of database field. As the user types the field they wish to search, all matching possibilities are shown for selection

that reads the results of the web form. Pseudocode for the algorithm is given in [Figure 2].

Additional algorithms were added as needed. For example, an algorithm was developed that automatically calculates the S (serum) stage for testicular tumors based on the values of lactate dehydrogenase (LDH), alpha-fetoprotein (AFP) and human chorionic gonadotropin.

A separate page was written for database query using standard SQL commands, generally searching for *field contains value*. The interface is enabled for autocompletion with Asynchronous Javascript and XML (AJAX), such that as the user types the field they can see all fields containing the typed characters and choose one [Figure 5], and as the user types the value, the database is queried for all values containing the typed characters for that field [Figure 6]. This helps to eliminate unsuccessful searches that will not actually find what the user is looking for. Results are then returned in a table [Figure 7].

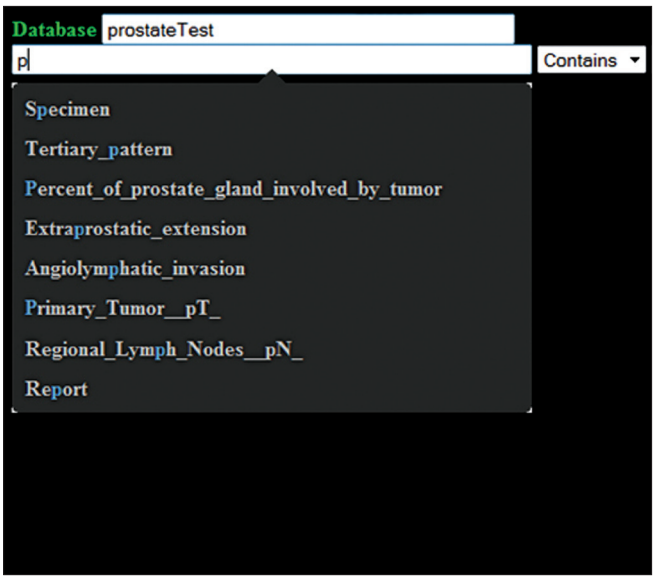


Figure 6: Database search page with autocompletion of search. As the user types the search term they wish to use, the database is queried to find all existing entries that match the current search text

RESULTS

The synoptic reporting system is available on the Internet.[12] This public version does not have databasing capabilities. At present, 31 synoptic report generators are available, mostly for cancer-based synoptic reporting. Additional forms have also been generated for KRAS mutation reporting results, UroVysion™ FISH reports and bone marrow biopsy and aspirate reports.

The web-based method allows access to the synoptic report elements at any computer workstation. An appropriate template is selected from a list on the main page. Once opened the synoptic report generator will display all options for elements in the final pathology report. After the appropriate selections are made, the pathologist enters the submit button, which generates a formatted report that omits all of the non-selected elements and adds basic formatting such as tab delimiting. If an error is noted at this stage (for example, the wrong checkbox was selected), the user can use the browser's back button to make the necessary change and re-submit the report. The HTML page that is generated can then be viewed before the text is cut and pasted into the Microsoft® Word® based text editor for our anatomic pathology information system (PowerPath® Elekta Software).

The output from this system can simultaneously be saved into a database that contains all of the entered elements and is searchable using standard SQL commands.

Database_Number	1
Time	2010-07-19 13:12:47
Institution	University of Florida (UF)
Accession_Number	F10-555555
Age	50
Gender	Male
Medical_Record_Number	0000000001
Clinical_History	Dude with prostate cancer
Specimen	Prostate, radical prostatectomy
Tumor	Prostatic adenocarcinoma
Gleason_score	3 + 4 = 7
Tertiary_pattern	5, 50
Maximal_tumor_nodule_diameter_measured_on_one_level__cm_	1.5
Multifocal_tumor	Y
Location_of_dominant_tumor_s_	R Base
Percent_of_prostate_gland_involved_by_tumor	75
Extraprostatic_extension	Absent
Margins	Margins positive for invasive carcinoma: Apical
Angiolymphatic_invasion	Present
Seminal_vesicle_invasion	Present
Primary_Tumor__pT_	pT2x: Organ confined, but extends to margin more than focally
Regional_Lymph_Nodes__pN_	pN1: Metastasis in regional lymph node or nodes (1 / 12)
Report	Specimen: Prostate, radical prostatectomy Tumor: Prostatic adenocarcinoma Gleason score: 3 + 4 = 7 Tertiary pattern 5, 50 % Maximal tumor nodule diameter measured on one level (cm): 1.5 Multifocal tumor: Y Location of dominant tumor(s): R Base Percent of prostate gland involved by tumor: 75 % Extraprostatic extension: Absent Margins: Margins positive for invasive carcinoma: Apical Angiolymphatic invasion: Present Seminal vesicle invasion: Present Pathologic Staging (pTNM) 7th edition AJCC Primary Tumor (pT): pT2x: Organ confined, but extends to margin more than focally Regional Lymph Nodes (pN): pN1: Metastasis in regional lymph node or nodes (1 / 12)

Figure 7: Database search output. Matching cases are displayed in a table

DISCUSSION

We have developed a web-based synoptic reporting system that we believe has several advantages over traditional dictated or manually entered reporting. First, by using radio buttons or checkboxes, we minimize the amount of typing necessary for generating the final pathology report. This significantly reduces typographical errors and standardizes the reporting language among pathologists, thus minimizing potential misunderstanding in cancer reporting.

Second, since the system allows simple cut-and-pasting into any text-based anatomic pathology LIS, the amount of transcription and associated errors is minimized. If, for example, one were to print out the checklist elements, manually fill them in and then submit these for transcription, this would introduce multiple additional steps in which an error could take place. In addition, the pathologist would still have to closely review all of the elements in the report to make sure that they agreed with those submitted.

Third, since the system is web-based it can be accessed at any computer workstation so no special software is required. This system is compatible with all major internet browsers, including Internet Explorer version 8 (Microsoft Corporation, Redmond, WA); Firefox version 3.6 (Mozilla, Mountain View, CA); Google Chrome version 8 (Google, Mountain View, CA); Safari 5 (Apple, Cupertino, CA); and Opera 11 (Opera Software, Oslo, Norway).

Fourth, this system allows seamless databasing of elements and does not require an additional step to enter the elements in the database. The presence on the web does present possible personal health information issues, but the database is stored on our secure departmental server, can be accessed only with a login, and includes accession number but no other identifiable information. There is some redundancy in that we have the information stored in both the pathology laboratory information system (LIS) and in this database. Presently, our separate database system allows specific queries of each individual reported field, while our primary LIS does

not. Having two separate systems does allow for some potential discrepancies should the user modify the report before saving it in the main system.

The output of this system is compatible with any anatomic pathology LIS that utilizes a text editor. Many of the newer versions of the anatomic pathology LIS have the option of directly embedding synoptic cancer reports based on the CAP checklists. Ideally, this would also be linked to the patient clinical, laboratory and radiologic data in the hospital wide LIS; such a system would be particularly advantageous for clinical research and outcomes based research. There are advantages, however, to having a standalone system. Principal among these is that our system is very flexible and can be readily changed or adapted to suit the needs of a particular institution. Also, the update of these checklists can be readily achieved by modifications to the text-based template from which the web code is generated. One particular advantage of the system we developed is that it can quickly convert a Microsoft® Word® or other text-based document into a web-based synoptic checklist by automating the generation of the code for the web form.

One weakness is that using these checklists requires the extra step of switching to our system, then copying the results to the original pathology information system. For systems in which synoptic checklists are embedded within the anatomic pathology LIS, this system in built in. For a Microsoft® Word®-based system, macros could conceivably be developed to open the browser to a requested checklist and retrieve the results.

Though not the primary goal during the initial development of this system, it became apparent that the system could easily be adapted for synoptic reporting in non-cancer specimens and non-anatomic pathology specimens. For example, we employ this system for reporting KRAS mutations and have begun using it for reporting UroVysion™ FISH results. We have begun developing simplified synoptic style reports for our hematopathology specimens, in particular bone marrow biopsy and aspirate reports and flow cytometry reporting. In addition, this system is ideal to insert certain "canned" comments.

In summary, the main advantages of this system are ease of creation and alteration of checklists, and the ability to use them at any workstation and with any text-based pathology information system. The main drawback is the lack of unification with the main system and the need to switch between the two.

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