CADTH

CADTH ENVIRONMENTAL SCAN REPORT

Approaches to Diagnosing Acute Pulmonary Embolism in Canada: current practice, challenges, and availability of testing

Authors: Sarah Garland and Melissa Severn
Cite as: Approaches to Diagnosing Acute Pulmonary Embolism in Canada: current practice, challenges, and availability of testing. CADTH; 2017 June. (Environmental Scan; Draft).

****

The Canadian Agency for Drugs and Technologies in Health (CADTH) takes sole responsibility for the final form and content of this environmental scan. The statements and conclusions in this environmental scan are those of CADTH. Production of this report is made possible by financial contributions from Health Canada and the governments of Alberta, British Columbia, Manitoba, New Brunswick, Newfoundland and Labrador, Northwest Territories, Nova Scotia, Nunavut, Prince Edward Island, Saskatchewan, and Yukon. CADTH takes sole responsibility for the final form and content of this report. The views expressed herein do not necessarily represent the views of Health Canada or any provincial or territorial government.

****

Canadian Agency for Drugs and Technologies in Health (CADTH)
600-865 Carling Avenue, Ottawa, Ontario K1S 5S8

Context

Venous thromboembolism (VTE) is the third most common cardiovascular disease after heart attack and stroke.[1] VTE encompasses two conditions: deep vein thrombosis (DVT) and pulmonary embolism (PE).[1,2] In 2012, it was estimated that 1,076 Canadians died from pulmonary heart disease and disease of the pulmonary circulation, with 602 (55.9%) of these deaths due to PE.[3] PE occurs when a blood clot that has formed in a vein, dislodges and travels to the blood vessels of the lung where it creates a blockage. There is a higher risk of experiencing PE, or VTE in general, in persons who have had surgery, are immobile, have experienced a physical trauma, are pregnant, or are using oral contraceptives or hormone replacement therapy.[1] However it should be noted that acute PE may still happen in the absence of these risk factors.[1]

The diagnosis of PE can be challenging as patients often present with symptoms that could be due to other conditions and are not specific to PE.[1] For example, patients with PE may have difficulty breathing, experience coughing, chest pain, and swelling or pain of the calf or thigh.[1,4] Prompt diagnosis is essential, as untreated PE is fatal in up to 30% of patients; though with timely diagnosis and treatment the mortality rate is 2% to 10%.[2] A combination of clinical prediction rules, laboratory tests, and imaging modalities is often used to diagnose PE.[2]

The first step in diagnosing suspected acute PE is often the use of a clinical prediction rule. These prediction rules, also called pretest probability (PTP) or risk stratification rules, are assessments of the probability that a patient has acute PE.[1,2,4] For example, one of the most commonly used rules is the Wells score.[2,4] This rule stratifies patients into categories of probability for PE, either based on a two-category score (PE unlikely or PE likely) or based on a three-category score (low, moderate, or high probability of PE).[1] The information to determine a Wells score is easily obtained, but this rule has been criticized for being too subjective.[2] Another rule is the Geneva score, which similarly predicts a patients PE risk; the Geneva score is thought to be more objective and less open to physician judgment.[2]

In addition to the PTP rules, ancillary or rule-out tests are additional tests that may be used to aid in the diagnosis of acute PE. One of these is the PE rule-out criteria (PERC), typically performed if a patient has a low risk PTP, which is a further set of eight criteria (e.g., no prior PE or DVT, age less than 50 years).[4] If all eight are fulfilled then no further testing is recommended.[4] Arterial blood gas is another test that may be performed; abnormal arterial blood gas is common in PE patients, but this test is not specific nor sensitive enough to get a definitive diagnosis.[4] Chest X-ray may also be performed, as these are commonly abnormal in persons with suspected PE, but like arterial blood gas, this is neither sensitive nor specific enough to be diagnostic.[4]

D-dimer, another rule-out test, is often a first-line test in patients with low to moderate PTP for PE.[2] Normal D-dimer levels often rule-out PE, but elevated levels of D-dimer – levels of 500 ng/L or more[2,4] – are present when someone experiences acute thrombosis, such as PE.[1] For patients who have a low PTP for PE but have elevated D-dimer levels, diagnostic testing is recommended.[4]. However, D-dimer can be elevated because of other conditions, such as cancer, trauma, surgery, or necrosis.[1] Acute PE may also lead to signs that can be detected by echocardiography.[1] Like D-dimer, abnormal echocardiography may be the result of conditions other than acute PE, so it is not a definitive diagnosis.[1]

In addition to PTP, rule-out, and ancillary testing, patients may undergo diagnostic imaging to diagnose PE. This usually involves ventilation/perfusion scanning (also known as V/Q scanning) or computed tomography (CT). V/Q scanning may be preferred in patients with a contraindication to CT scanning (sometimes because of an allergy or reaction to the contrast used in CT), or to avoid unnecessary radiation. However, V/Q scanning still involves the use of an intravenous radioisotope, therefore patients are still exposed to some radiation when tested.[1] V/Q scans are considered diagnostic for PE.[2] Leg compression ultrasound can also be used when diagnosing PE, as in many cases acute PE originates from a lower limb DVT.[1] Ultrasound may show DVT in approximately 30% to 50% of patients with suspected PE, and if found, may warrant treatment without further testing.[1]

Single photon emission computed tomography (SPECT) may be used for diagnosing PE. A recent guideline found evidence to suggest that the use of SPECT may reduce the number of non-diagnostic scans compared to V/Q scanning.[1] Magnetic resonance imaging (MRI) may also be used in the diagnosis of PE, however, this may depend on availability of equipment, and may be inferior to CT for detecting PE.[1]

A combination of PTP, rule-out or ancillary tests, and diagnostic imaging is typically used to diagnose PE. With the number of tests and imaging tools to diagnosis acute PE, it is clear there are many approaches to diagnosing PE. The purpose of this Environmental Scan is to provide information regarding current practice, challenges to PE diagnosis, and the availability of testing to diagnose acute PE in patients in various settings within Canada.

Objectives

This report summarizes information obtained through a literature search and a survey of key informants. The objectives of the Environmental Scan are to:

1. Identify current practice related to diagnostic strategies for PE in Canada
2. Identify which tests, scans and tools are available across Canadian jurisdictions and settings (i.e., urban, rural, and remote health care centres) to diagnose PE
3. Identify challenges and enablers to the diagnosis of PE, including relevant implementation issues in Canada

Methods

The findings presented in this Environmental Scan are informed by a limited literature search and responses to the Approaches to Diagnosing Acute Pulmonary Embolism in Canada Environmental Scan Survey (Appendix 1), gathered between December 5, 2016 and January 20, 2017.

The literature search was performed by an information specialist, using a peer-reviewed search strategy. Published literature was identified by searching the following bibliographic databases: MEDLINE (1946-) and Embase (1974-) via Ovid; Cumulative Index to Nursing and Allied Health Literature (CINAHL) via EBSCO; PubMed and Scopus. The search strategy was comprised of both controlled vocabulary, such as the National Library of Medicine's MeSH (Medical Subject Headings), and keywords. The main search concepts were pulmonary embolism and implementation issues. A filter was applied to limit retrieval to Canadian studies, which were deemed most relevant to this Environmental Scan as the aim was to assess approaches to diagnosis in Canada. Retrieval was limited to documents published since January 1, 2006. The search was limited to English- or French-language publications. Conference abstracts were excluded from the search results.

Grey literature (literature not commercially published) was identified by searching the *Grey Matters* checklist (https://www.cadth.ca/grey-matters), which includes the websites of HTA agencies, clinical guideline repositories, SR repositories, economics-related resources, patient-related groups, and professional associations. Google and other Internet search engines were used to search for additional web-based materials.

Study selection for the database and grey literature searches followed the criteria outlined in Table 1

Table 1: Selection Criteria for Literature Search

Population	Adult patients (≥ 18 years) undergoing testing for PE*
Setting	Urban, rural and remote health care centres where persons are presenting for suspected PE
Intervention	Tests and tools for PE diagnosis (e.g., Wells Criteria, V/Q scanning, etc.)
Results	Current clinical practice strategies, challenges and enablers of diagnosing PE, availability of tools for PE diagnosis, other issues of relevance to implementation of optimal PE imaging strategies

*Of note, some studies were included if they considered VTE patients in general, as this included PE patients; however, studies regarding solely DVT patients were excluded. PE specific information, if provided in the VTE studies, was emphasized.
PE = pulmonary embolism; V/Q = ventilation perfusion

In addition to the literature search, a 13 question survey was developed to provide additional information and context on this topic. The survey, provided in Appendix 1, included dichotomous, nominal, and free-text questions. Quantitative dichotomous (for example, Yes/No) and nominal variables (for example, a list of options) were summarized descriptively by jurisdiction. Open-ended qualitative responses were categorized by theme and summarized narratively. The final survey was distributed via email to potential respondents.

One or more survey respondents from each province and territory, with the exception of the Northwest Territories where no potential respondent was identified, were contacted to complete the survey. Seventy people were initially sent the survey, and survey recipients were asked to further distribute the survey to their colleagues, as appropriate. Survey respondents were identified by CADTH Liaison Officers, through professional and clinical networks, or referred through other respondents.

To supplement the findings of the survey and the literature search, a consultation with a clinical expert in the field of emergency medicine was conducted. This consultation centred on the expert views of the approach to diagnosing pulmonary embolism, including challenges to diagnosis and the Canadian context. A semi-structured interview approach was used, and the consultation lasted for approximately 45 minutes.

Findings

The findings of this report are presented by the objectives listed above.

Nine primary studies were included in the summary of the literature. Appendix 2 presents the study characteristics for the articles included in this Environmental Scan.

Regarding the survey, twelve responses were received from five jurisdictions. Four responses were received from Manitoba, three from New Brunswick, two from Prince Edward Island (PEI), two from Saskatchewan, and one from Ontario. No responses were received from the remaining Canadian jurisdictions. Appendix 3 provides additional information on the survey respondents.

Data tables for the survey responses are provided in Appendix 4.

Diagnostic Approach

Literature

Several studies detailed an overall diagnostic approach to diagnosing PE. Four studies of the identified literature used the Wells model as a diagnostic strategy for diagnosing suspected PE.[5-8] This model included a clinical assessment (e.g., PTP rule), to determine if PE is likely or unlikely, as a first step.[5,6] Patients with clinically unlikely PE then undergo D-dimer testing (D-dimer as specified by the two studies: highly sensitive latex immunoassay D-dimer[6] and quantitative latex agglutination test D-dimer technique [IL test™][5]); if D-dimer is negative, no further testing is warranted.[5,6] If D-dimer is positive, then patients undergo additionally imaging such as CT or V/Q.[5,6] For patients in whom PE is likely (i.e., high PTP score), diagnostic imaging is recommended (e.g., V/Q scan or CT). Additionally diagnostic tests (e.g., pulmonary angiogram[5] or ultrasound[5,6]) may be required if the first is indeterminate. One study[9] cited the American College of Chest Physician guidelines for diagnosing PE, which is similar to Wells.

The remaining studies focused on one aspect of the diagnostic pathway (e.g., rule-out testing, imaging) and not the pathway as a whole. Four studies focused on diagnostic imaging for PE, as part of the diagnostic pathway.[10-13]

Survey

Survey participants were first asked about their general approach to diagnosing acute PE. Six survey participants (Manitoba, Ontario, New Brunswick, and PEI) indicated that patients are assessed by emergency physicians, primary care physicians, or other specialists to determine their risk probability, though only one participant mentioned a specific clinical prediction tool (Wells Criteria) in this portion of the survey (when directly asked about PTP, more participants indicated they were aware of Wells Criteria). D-dimer may also be used in the diagnostic approach in some facilities, as stated by three respondents from Manitoba, and one respondent from PEI. There was some indication that D-dimer might be used as a screening tool, as indicated by one of these responses. One participant (PEI) said that the use of an electrocardiogram, with or without bedside ultrasound, may also be used in the diagnosis of PE. Another participant (Ontario) mentioned that leg Doppler ultrasound may be used.

V/Q scans may be a part of PE diagnosis in several facilities, as indicated by three respondents (two from Manitoba, one from Saskatchewan). The use of CT was mentioned by nine survey participants (four from Manitoba, one from New Brunswick, two from PEI, one from Saskatchewan, and one from Ontario), suggesting its common use in the diagnosis of PE. Two participants (PEI and Manitoba) stated that they had a CT scan with a protocol to diagnose PE. One respondent (Manitoba) indicated that CT was their facility's "gold standard" when it came to PE diagnosis.

One participant (Saskatchewan) mentioned the use of American College of Chest Physician guidelines (no further details provided). No other participants stated the use of guidelines for PE diagnosis, though this may only be reflective of the facility or particular respondent and not of their jurisdiction.

Participants were also asked if they were aware of instances when their diagnostic strategy may differ depending on location within their jurisdiction (e.g., urban, rural, remote hospitals). Seven respondents indicated that how a diagnosis is made may change depending on the availability of tools and tests within their jurisdictions. The respondents from Manitoba stated the diagnostic strategy may differ depending on availability of D-dimer, V/Q and CT scans or nuclear medicine. One respondent from New Brunswick suspected that larger facilities may have different approaches, and another respondent from this jurisdiction stated that some facilities do not have CT scans or nuclear medicine departments. Both respondents from PEI indicated that patients seen in rural sites requiring CT scans would need to be transferred to one of two hospitals with CT scans in the province. Similarly, one respondent from Saskatchewan mentioned that rural sites do not have CT or V/Q available.

In addition to different approaches based on location, survey participants were asked if the diagnostic approach may differ based on particular patient populations. Seven participants (Manitoba, New Brunswick, PEI, and Saskatchewan) indicated that CT imaging may be difficult if patients have renal dysfunction, or an allergy or contraindication to the contrast used. Two participants (PEI and Manitoba) mentioned V/Q scan, echocardiography, or leg ultrasounds are available in this case. One participant (PEI) mentioned that if patients are not able to have contrast CT, and are presumed to be high risk for PE, they may be treated if treatment is deemed less risky than investigation. Two participants (Ontario and PEI) indicated that pregnant women are a special population; one participant specifically indicated that pregnant women are informed of any risk and ask for their consent. One participant (Saskatchewan) indicated that patients with morbid obesity may be beyond the weight limit of imaging scanners; no alternative diagnostic method was specified.

Based on these questions that aimed to assess general approaches to diagnosing PE, there appears to be some commonalities. CT scan was one of the most frequently mentioned imaging modalities for PE diagnosis. As well, respondents were aware that rural hospitals may not have the same tools and tests as urban hospitals; this may require transportation of patients (discussed in more detailed in another section of this report). Additionally, diagnostic approaches may differ depending on characteristics of the patient (e.g., contrast allergy, pregnancy, morbid obesity).

Risk Stratification and Pretest Probability

Literature

Findings from several of the studies suggest that PTP, if done, is poorly documented in patient charts.[5-8] This appears to be the case for large, academic, tertiary care hospitals[5,8] as well as a small, rural hospital.[7]

The study by Ballantine et al.[7] examined the diagnostic approach to PE in a rural hospital in Ontario. Out of the 47 charts reviewed, the authors concluded that one chart (2.1%) had appropriate documentation to be able to calculate a Wells Score. Overall they stated that there was a lack of documented PTP and suggested implementing a protocol that required the use of Wells scores before any further testing or imaging was ordered; their primary concern was the over-use of D-dimer and other tests.[7] These findings are similar to the study by Aranson et al.,[5] where PTP was calculated and documented in 166 of 863 charts (19.2%) of patients with suspected VTE in a large, academic hospital. It is uncertain which of the 166 documented PTP scores were for suspected PE versus DVT patients as this specific information was not provided, though the study authors were able to calculate a PTP score from information in the chart.[5] This is similar to the study by Smith et al.,[8] where less than half of their charts (35 of 97 charts [36.1%]) with suspected DVT or PE had documented PTP by Wells' score or another PTP tool.

In the study by Ingber et al.,[6] the study authors investigated the initiation of mandatory PTP algorithms (based on Wells Criteria). Patients with low PTP would go on to have D-dimer testing, which if negative, ruled-out VTE and no further testing was recommended. If patients had a moderate or high PTP score, they would go on to imaging (CTPA or V/Q scan) without D-dimer testing.[6] The authors were primarily interested in the use of D-dimer and imaging tests in the pre- and post-intervention periods, but they also demonstrated that the initiation of mandatory PTP testing was feasible given a high degree of compliance. This required collaboration with the emergency department and with their laboratory; D-dimer samples had to have a PTP score sheet in order to be tested, and those without would not be tested.[6]

Though it appears that PTP is rarely documented, if done, it is possible to establish mandatory PTP assessment. This would require collaboration across departments.

Survey and Consultation

The survey asked questions about the various tools that are currently in use to determine pretest probability and risk stratification for suspected PE patients (see

Table 2). Of the respondents who could adequately answer this question (two replied that this was out of their clinical scope), two respondents (one each from PEI and Saskatchewan) used PERC, four respondents (one each from Manitoba, PEI, Ontario, and Saskatchewan) used or were aware of others who used Wells' Criteria for PE, one respondent (PEI) used the Geneva score, and four respondents (two from Manitoba, one from New Brunswick, and one from Saskatchewan) replied that they did not use any of the tools mentioned. One respondent from Manitoba and one respondent from New Brunswick both replied that the use of any particular risk stratification tool was primarily driven by whatever the clinician was most familiar with.

In the consultation with a clinical expert, challenges to pretest probability testing were discussed (Dr. Eddy Lang, Academic Department Head and Professor at the University of Calgary Cumming School of Medicine, Calgary, AB: personal communication, 2017 April 21). The issue was raised that PTP is typically not memorized by physicians, and it can be difficult to incorporate into a busy emergency department. It may be that physicians are more likely to document whether a patient was PERC negative, to demonstrate due diligence, especially if a patient were to be diagnosed with PE in the future. Additionally, it was noted that there is not much literature regarding clinical gestalt to diagnosis PE compared to a structured approach of PTP.

Additionally it was discussed how recent recommendations from Choosing Wisely Canada,[14,15] which recommend the judicious use of resources when diagnosing PE, are in part related to the appropriate use of PTP (Dr. Eddy Lang: personal communication, 2017 April). The relevant recommendation for PTP

states, *"Don't order CT pulmonary angiograms or VQ scans in patients with suspected [PE] until risk stratification with decision rule out has been applied and when indicated, D-dimer biomarker results are obtained."*[15]

Rule-Out and Ancillary Testing

Literature

Regarding rule-out and ancillary testing, a few studies focused on the use of D-dimer testing, or more specifically, the overuse of D-dimer testing. Overuse of D-dimer was the suspicion for a rural hospital[7] as well as large, urban hospitals.[5,8]

The authors of the study regarding PE diagnosis in a rural emergency department suspected that D-dimer was being inappropriately used in their setting (39 out of 47 charts [83%] had D-dimer ordered); based on this and the authors' previous experience, it is likely that high-probability patients had D-dimer ordered, but the lack of PTP documentation made this uncertain.[7] For this emergency department, chest radiography was ordered in 87.2% of cases and bilateral leg Doppler ultrasonography was ordered in 14.9% of cases.[7]

The study by Smith et al. investigated 97 charts for which the patient had been ordered D-dimer (SimpliRED D-dimer).[8] Similarly, this study found that D-dimer was not being used as recommended, or was being misinterpreted by emergency clinicians.[8] This included: follow-up diagnostic imaging for patients with negative D-dimer (15 cases without PTP documentation); diagnostic imaging for patients with low or moderate PTP and negative D-dimer (three cases); D-dimer for a patient with high PTP (one case); and no follow-up diagnostic imaging for patients with a positive D-dimer (five cases).[8]

Additionally, the study by Arnason et al.[5] regarded the use of appropriate diagnostic strategies for VTE and reviewed 863 charts of patients for whom D-dimer had been ordered. The authors reviewed diagnostic imaging for patients that had D-dimer testing, and suspected that D-dimer was being used as an initial screening tool for patients with chest pains, regardless of their clinical presentation.[5] The study authors noted that the prevalence of PE was lower than expected, and thought this may have been due to the use of D-dimer in patients before PE had been considered a possible diagnosis.[5]

The study by Ingber et al.[6] explored other findings related to D-dimer use (latex immunoassay – HemosIL D-dimer, Instrumentation Laboratory Company, Bedford, MA). The study authors found that clinicians were compliant with their diagnostic algorithm as 95% (428 out of 449) of the D-dimer requests had PTP documentation. However, the use of diagnostic imaging for VTE did not decrease in this study, even though PTP was now required for D-dimer testing.[6] The authors suspected that this might be partly due to the high false positive rates of the test they were using, and further emphasized using a local cut-off value (rather than the manufacturer cut-off), as well as an age-adjusted cut-off.[6] Use of more appropriate cut-offs may have resulted in more low PTP patients in whom VTE might have been ruled-out.[6]

More generally, the study by Southern et al.[9] considered access to D-dimer testing, through a survey and interviews of key stakeholders for all acute care hospitals in Canada. As a general trend, provinces with small populations were more likely to collect samples for D-dimer testing and send them to centralized facilities to be analyzed, whereas provinces with large populations had more hospitals with on-site D-dimer testing. Yukon had the most limited access to D-dimer testing, either on-site or sent to a centralized facility (30% of sites had access to D-dimer testing); this was followed by Nunavut (50% of sites had access to D-dimer testing).[5] According to the study authors, 100% of hospitals in Ontario, Nova Scotia, PEI, Newfoundland, and the Northwest Territories had access to D-dimer testing (either on-site or through a centralized facility). These were followed by (in descending order of access) by Alberta, Manitoba, Saskatchewan, Quebec, New Brunswick, BC, Nunavut, and the Yukon.[9]

The study by Southern et al.[9] also explored access to Doppler ultrasonography. The Northwest Territories, Nunavut and the Yukon only had limited access, meaning less than 24 hours a day for seven days a week (i.e., 24/7) access. All other jurisdictions had at least one hospital with 24/7 access to

Doppler ultrasonography.[9] This ranged from 88% of hospitals with 24/7 access in Quebec, to 6% of hospitals with 24/7 access in Manitoba.[9]

Survey and Consultation

Survey respondents were asked about the availability of rule-out and ancillary tests in their jurisdiction, including: arterial blood gas, capnography, chest X-ray, D-dimer testing, echocardiography, electrocardiography, and leg compression ultrasound. The responses are displayed in Table 3. All provinces that provided responses had access to at least some of these tests. New Brunswick and Saskatchewan, based on responses from survey respondents, did not have capnography; though this may be a reflection of the facilities where the respondents were located and not for the provinces as a whole.

Similarly to the literature, the clinical expert also mentioned that D-dimer may have high false positives in certain populations (e.g., the elderly, patients with auto-immune or inflammatory disease) (Dr. Eddy Lang: personal communication, 2017 April). While our survey attempted to address what type of D-dimer was being used (e.g., age-adjusted), the response rate was too low to determine what is being used across Canada; this is an information gap.

Imaging Modalities

Literature

The findings in the literature regarding imaging modalities for PE diagnosis varied.

The study by Ballantine et al., regarding the rural emergency department, noted that some patients, 40.4% and 31.9%, had CT and V/Q ordered, respectively.[7] Both CT and V/Q were ordered in 14.9% of the charts, and in these cases, CT was ordered in follow-up to V/Q to provide a definitive diagnosis.[7] Overall, the authors noted that physicians seemed to prefer CT to diagnose PE, however, they were not certain whether this was because of the perceived ease of access to CT.[7] Another potential reason, as suggested by Southern et al.,[9] may be that CT is more readily available in smaller centres.

The study by Le Roux et al.[10] explored the use of SPECT or SPECT/CT instead of planar scintigraphy for the diagnosis of PE. Forty-eight Canadian sites were surveyed (no provinces or territories specified), of which, 77% routinely used V/Q SPECT in diagnosing suspected acute PE. Of these centres, 23% used V/Q planar, 65% used V/Q SPECT, and 6% used V/Q SPECT-CT.[10] V/Q planar was primarily interpreted using the European Association of Nuclear Medicine criteria (60%), followed by binary one sub-segment (17%), probabilistic Prospective Investigation of PE Diagnosis study criteria (17%), or no standardized criteria (7%). Additionally, for the V/Q radiopharmaceutical (i.e., ventilator component) used, 17% of centres used ^{99m}Tc-diethylene triamine pentaacetic acid (DTPA), and 79% used ^{99m}Tc-labelled technegas. The study authors concluded that in the study (which also considered practices in France and Australia), SPECT has largely replaced planar imaging when it comes to PE diagnosis.[10] However, they did note some resistance to the adoption of SPECT technology (not specific to Canada but a trend in the overall study) which they suspected was because of several reasons, including: reluctance to change, more experience and familiarity with planar imaging, possible concerns related to time for SPECT, lack of appropriate imaging agents, or resistance from other colleagues.[10]

Several studies focused primarily on the use of CT for the diagnosis of PE.[11-13] When choosing between V/Q scanning or CTPA, emergency physicians may give consideration to the radiation risk of either of these tests; the radiation dose of CTPA is estimated to be five times that of V/Q scan.[11] In a study by Ahn et al., emergency physicians (n = 43) had a general knowledge that a V/Q scan exposed patients to less radiation than CTPA, and they preferentially chose V/Q scans for younger patients (< 50 years old), females, or if they had a history of recent, multiple CT scans.[11] However, physicians had limited knowledge of precise radiation dose, and the study authors did not explore whether radiation risk had been discussed with the patients.[11]

One study examined CTPA utilization rate, and PE incidence rates, among 26 emergency physicians of different genders and ages, with training in either a three year Canadian College of Family Physicians Certificate of Special Competence in Emergency Medicine or a five year Fellowship of the Royal College

of Physicians in Emergency Medicine.[12] Physician gender, years of practice, and training certification was not correlated with CTPA utilization rate or with PE positivity rate.[12] However, CTPA utilization rates differed amongst physicians, with a range of 0.21 to 0.77 scans per 100 patient visits (average of 0.48 scans per 100 patient visits).[12] The authors of this study listed several factors that may influence how often CTPA is used, including, physicians' knowledge of guidelines, risk tolerance, prior training, prior experiences, and the "need to know".[12] Also related to how often a physician may use CTPA in the diagnostic work up of PE, is the availability of the tests, time constraints, and possible concerns over litigation.[12] While the authors did not specifically look at appropriate use of CTPA and the source of the inter-physician variation in use rates, there were some speculated differences in adherence to guidelines; they suggest future efforts be focused on physician education.[12]

Spencer Netto et al.,[13] assessed at the use of contrast-enhanced chest CT as part of trauma assessment. The increased use of CT for imaging of trauma patients increased the diagnosis of asymptomatic PE.[13] These patients were not started on anticoagulant therapy, as the authors found evidence to suggest that anticoagulation therapy may increase adverse outcomes.[13]

The study by Southern et al.,[9] provided a cross-Canada picture of access to V/Q, spiral CT, venography and pulmonary angiography for the diagnosis of VTE. In terms of general trends, the study authors noted that V/Q scanning and pulmonary angiography were more frequently available in larger, urban centres, whereas CT was available in more centres across the country. For CT, most of the centres offered 24/7 access. The authors noted that there was no CT scanner in Nunavut at the time of their data collection (2009).[9] CADTH's Canadian Medical Imaging Inventory (CMII)[16] provides a more recent estimate (2015) and there is one CT scanner in Nunavut. Whether the scanner is used for patients with suspected PE is not known. The Northwest Territories and the Yukon also have one CT scanner each.[9,16]

The CMII provides recent data on the number of CT, MRI, PET, and SPECT units across the country (with information on the number of hours these units are available per day and per week), however, whether these are indicated for use in patients with suspected PE is not known. As of the 2015 data, there are 538 CT units, 340 MRIs, 264 SPECT, 47 PET or hybrid PET-CT, and 214 SPECT-CT units across Canada; for all of these imaging modalities, the most units were found in Ontario and Quebec. There are also two PET-MRI units in Canada, both of which are found in Ontario and operate for research purposes only.[16]

V/Q scanning and pulmonary angiography were not available in the territories or Nunavut.[9] For the other jurisdictions, PEI and Manitoba only had centres with limited (less than 24/7) access to pulmonary angiography.[9] For V/Q scanning, Manitoba only had centres with limited access; all other provinces, had at least one centre with 24/7 access to V/Q scanning. Venography, imaging for veins, was available in every jurisdiction except the Northwest Territories.[9] Additionally, PEI, Nunavut and the Yukon only had centres with limited access to venography.[9]

Survey

Survey respondents were asked about the availability of imaging tests in their jurisdiction, including: V/Q scintigraphy, V/Q SPECT, V/Q SPECT-CT, CT, thoracic ultrasound, MRI, and PET. The responses are displayed in

Table 4. All jurisdictions had access to at least some of these tests. Only the hospital in Ontario had access to all of the imaging modalities. New Brunswick was the jurisdiction with responses from both an urban teaching hospital and a rural hospital; only CT and MRI were available at the rural hospital, while the urban, teaching hospital had the V/Q modalities, CT, and MRI.

Resources, Challenges to Diagnosis, and Transportation of Patients

Access to Resources

Survey

Survey participants were asked whether their diagnostic approach would change if they had more or different resources available. One respondent stated they had enough resources, three respondents indicated that their approach would not change with other or additional resources, and six respondents did not answer the question. One respondent (New Brunswick) indicated that having more staff after hours may enable them to do more nuclear scans. One respondent (PEI) stated that they are generally satisfied with their tools to diagnose PE, but that access to V/Q scans is limited after hours.

Challenges to Diagnosis

Survey and Consultation

Survey participants were also asked about any particular challenges they might face when diagnosing PE, beyond access to additional resources. Three respondents did not answer the question and one respondent was not aware of any challenges. For those that did answer, there was some overlap in response. Four respondents indicated that the challenges were primarily clinical. Two of these respondents indicated that challenges arise from the lack of assessment (unspecified), or assessment related issues, by clinical staff. One of these respondents stated that there is an over-reliance on imaging for PE diagnosis. Two other respondents indicated that the main challenge is in considering PE as a diagnosis, as this may be overlooked when patients experience chest complaints, which may then be attributed to other conditions.

Other challenges were also mentioned. One participant from Manitoba stated that clear protocols are needed for small and medium sized communities. As briefly mentioned before, one respondent from New Brunswick indicated that nuclear scans are a limiting step, as only one radiologist is available to read them. As well, one participant from Manitoba stated that patients are sometimes too unstable to get a CT scan if needed.

In consultation, the clinical expert discussed general challenges to diagnosing PE, specifically that most patients with PE present atypically, and that it can be hard to diagnose. It was suggested that most patients with PE do not get diagnosed on their first visit to their doctor or the emergency department. Similarly to the survey respondents, the expert also indicated that failure to consider PE as a diagnosis is a challenge; this lack of consideration could result in near misses or potential fatalities when patients fail to be appropriately diagnosed with PE. This fear of missing PE may also cause physicians to start treating patients with anticoagulants, as a bleed complication from being treated is thought by some to be preferable to having PE (Dr. Eddy Lang: personal communication, 2017 April).

Transportation of Patients Out of Centre for PE Diagnosis

Literature

In the literature, the study by Ballantine et al., discussed transportation of patients out of their facility.[7] The hospital in the study, South Huron Hospital in Exeter Ontario, does not have CT or onsite nuclear medicine. Patients requiring V/Q are transferred to London, Ontario (45 km away), and those requiring CT are transferred to London, Stratford (50 km away) or Strathroy, Ontario (55 km away).[7] Stratford, Ontario also offers V/Q,[7] though it was not clear whether patients from South Huron are transferred there for this service. The mean time for patients receiving CT was 1.59 days, and 1.58 days for V/Q.[7] Transportation costs, and other issues related to patient transfer, were not discussed by the study authors.

Survey and Consultation

Finally, survey respondents were asked about transportation of patients out of centre for PE diagnosis. One survey respondent from Manitoba stated that they may transport patients out of their facility (all other respondents stated that they did not transfer out of their centre for PE diagnosis). These transportation costs were covered by the province, as patients were transferred via ambulance services. Another survey respondent from PEI, when discussing resources needed to diagnose PE, indicated that V/Q scans were not available after hours; however, they were a 45-minute transfer away if needed.

From the consultation with a clinical expert, patients in the North or from remote areas may be treated with anticoagulants in the interim, before they are able to be transported for further work-up (Dr. Eddy Lang: personal communication, 2017 April).

Limitations

The findings from the survey are not intended to provide a comprehensive review of the diagnosis of PE, but rather were intended to provide an overview of the current context in Canada (with the exception of the Northwest Territories). However, responses from numerous provinces and territories are missing, including British Columbia, Alberta, Yukon, the Northwest Territories, Quebec, Nova Scotia, Nunavut, and Newfoundland and Labrador. The responses of the survey participants are limited to their own perspectives and experiences, and may not accurately reflect the entire jurisdiction. There was also a low response rate (less than 20%) for the surveys, and likely does not provide a complete representation of practices in Canada.

Additionally, the scope of this report was limited to the diagnostic approach to PE. Treatment of PE, including anticoagulation therapy, was not explored. It may be that approaches to treating PE also differ across the country, though this was out of the scope of this document.

There were limited findings (from both the literature and survey responses) from the rural and remote perspectives. Many of the survey respondents were from large, urban centres, and the majority of the studies were from large centres in Ontario.

Expert opinion was solicited from one emergency physician. It is possible that further expert consultation, from other health care professionals, may elicit additional information.

Conclusion

Acute PE presents a diagnostic challenge. Patients with suspected acute PE often present with symptoms that could be caused by a number of different conditions and are not specific to PE. There are a myriad of tests and tools used to diagnose PE and which tests and tools are used may vary depending on several factors, including patient factors and availability of resources.

From both the literature and survey responses, the use of a formal PTP score may be limited, or is poorly documented. It seems that for PTP rules, it is not a matter of whether these tests are available, as there is no equipment needed to use them, but whether physicians who have knowledge of these tools, routinely use them, and document their use. Input from a clinical expert also suggested that the incorporation of formal testing into an emergency department can be challenging. Physicians may commonly use their clinical judgement or gestalt when assessing the likelihood of suspected PE in a specific patient, but the documented use of a formal PTP score such as Wells or Geneva is uncommon in some facilities. D-dimer may be more commonly used; but as both literature and survey responses suggest, this test may sometimes be used as a screening tool, rather than as a rule-out test. Additionally, false positives with D-dimer, especially for certain populations like the elderly or patients with auto-immune or inflammatory diseases, may make its use in these populations misleading.

Access to imaging tests, such as V/Q scanning, CT, SPECT or pulmonary angiography may be limited (i.e., less than 24/7 access or no access) or not available regionally. Survey responses, and findings from two Canadian studies[7,9] indicate that CT may be more widely available across Canada, while tests like V/Q scans, pulmonary angiography and MRI are located in larger, urban centres. Generally, imaging was

more limited or not available in the northern jurisdictions (Yukon, Northwest Territories, and Nunavut). Even if a province has imaging units, there may be limited access (i.e., less than 24 hours a day, every day of the week).

Patient characteristics may also dictate which tests and tools are used. The literature suggests that physicians may preferentially use V/Q, compared to CT, in an effort to reduce radiation dose in younger or female patients. A Choosing Wisely Canada recommendation is similar to this line of thinking, which supports the use of V/Q scanning in younger, female patients, as opposed to CT.[14] Survey responses indicated that patients with contraindications or contrast allergies to certain tests, as well as pregnancy, morbid obesity, and ability to get to a scanner influence which approaches are used to diagnose suspected PE.

Based on survey responses, challenges to PE diagnosis include access to tests and imaging modalities (i.e., limited access afterhours, or limited staff to read nuclear medicine scans), as well as lack of defined protocols for smaller facilities. In order to access imaging, patients may need to be transported to a larger facility; from both surveys and the literature, these transportations may not lead to an unreasonable delay in imaging, though more remote centres may find differently. There may also be a lack of initial clinical assessment, and an over reliance on diagnostic imaging, as suggested by both literature and survey responses.

This report provides a brief overview of some of the issues related to the diagnosis of acute PE in Canada. While not intending to provide a comprehensive review, this report does raise some issues regarding the diagnostic approaches to PE, the availability of tools and tests, and challenges and enablers to the diagnosis of PE, including relevant implementation issues in Canada.

References

1. Konstantinides SV, Torbicki A, Agnelli G, Danchin N, Fitzmaurice D, Galie N, et al. 2014 ESC guidelines on the diagnosis and management of acute pulmonary embolism. Eur Heart J [Internet]. 2014 Aug 29 [cited 2016 Aug 16]. Available from: http://eurheartj.oxfordjournals.org/content/ehj/early/2014/08/28/eurheartj.ehu283.full.pdf

2. Sadigh G, Kelly AM, Cronin P. Challenges, controversies, and hot topics in pulmonary embolism imaging. AJR Am J Roentgenol [Internet]. 2011 Mar [cited 2017 Jan 17];196(3):497-515. Available from: http://www.ajronline.org/doi/pdf/10.2214/AJR.10.5830

3. CANSIM [Internet]. Ottawa: Statistics Canada; 2015 Dec 10. Table 102-0529 - Deaths, by cause, Chapter IX: Diseases of the circulatory system (I00 to I99), age group and sex, Canada. [cited 2017 Jan 19]. Available from: http://www5.statcan.gc.ca/cansim/a26?lang=eng&id=1020529

4. Thompson BT. Clinical presentation, evaluation, and diagnosis of the adult with suspected acute pulmonary embolism. In: Post TW, editor. UpToDate [Internet]. Waltham (MA): UpToDate; 2016 Aug 8 [cited 2017 Jan 19]. Available from: www.uptodate.com Subscription required.

5. Arnason T, Wells PS, Forster AJ. Appropriateness of diagnostic strategies for evaluating suspected venous thromboembolism. Thromb Haemost. 2007 Feb;97(2):195-201.

6. Ingber S, Selby R, Lee J, Geerts W, Brnjac E. Combination pretest probability assessment and D-dimer did not reduce outpatient imaging for venous thromboembolism in a tertiary care hospital emergency department. CJEM Can J Emerg Med [Internet]. 2014 Jan [cited 2016 Dec 1];16(1):53-62. Available from: https://www.cambridge.org/core/services/aop-cambridge-core/content/view/E554192410CD97381E3D0F418682EB1A/S1481803500003328a.pdf/combination-pretest-probability-assessment-and-d-dimer-did-not-reduce-outpatient-imaging-for-venous-thromboembolism-in-a-tertiary-care-hospital-emergency-department.pdf

7. Ballantine M, Bhimani M, Milne K. Diagnostic approach to pulmonary embolism in a rural emergency department. Can J Rural Med [Internet]. 2012 [cited 2017 Jan 12];17(1):17-20. Available from: http://www.srpc.ca/PDF/cjrm/vol17n1/pg17.pdf

8. Smith C, Mensah A, Mal S, Worster A. Is pretest probability assessment on emergency department patients with suspected venous thromboembolism documented before SimpliRED D-dimer testing? CJEM Can J Emerg Med [Internet]. 2008 Nov [cited 2016 Dec 1];10(6):519-23. Available from: https://www.cambridge.org/core/services/aop-cambridge-core/content/view/7C0C2B88EA252A45B6B66296594E2758/S1481803500010733a.pdf/is-pretest-probability-assessment-on-emergency-department-patients-with-suspected-venous-thromboembolism-documented-before-simplired-dimer-testing.pdf

9. Southern DA, Poole J, Patel A, Waters N, Pilote L, Hull RD, et al. Health system capacity and infrastructure for adopting innovations to care for patients with venous thromboembolic disease. Open Med [Internet]. 2014 [cited 2016 Dec 1];8(2):e46-e53. Available from: http://www.ncbi.nlm.nih.gov/pmc/articles/PMC4085085

10. Le Roux PY, Pelletier-Galarneau M, De Laroche R, Hofman MS, Zuckier LS, Roach P, et al. Pulmonary scintigraphy for the diagnosis of acute pulmonary embolism: a survey of current practices in Australia, Canada, and France. J Nucl Med [Internet]. 2015 Aug [cited 2016 Dec 2];56(8):1212-7. Available from: http://jnm.snmjournals.org/content/56/8/1212.full.pdf+html

11. Ahn JS, Edmonds ML, McLeod SL, Dreyer JF. Familiarity with radiation exposure dose from diagnostic imaging for acute pulmonary embolism and current patterns of practice. CJEM Can J Emerg Med [Internet]. 2014 Sep [cited 2016 Nov 30];16(5):393-404. Available from: https://www.cambridge.org/core/services/aop-cambridge-core/content/view/S1481803500003079

12. Chen YA, Gray BG, Bandiera G, MacKinnon D, Deva DP. Variation in the utilization and positivity rates of CT pulmonary angiography among emergency physicians at a tertiary academic emergency department. Emerg Radiology. 2015 Jun;22(3):221-9.

13. Spencer Netto F, Tien H, Ng J, Ortega S, Scarpelini S, Rizoli SB, et al. Pulmonary emboli after blunt trauma: timing, clinical characteristics and natural history. Injury. 2012 Sep;43(9):1502-6.

14. Nuclear medicine: five things physicians and patients should question [Internet]. Toronto: Choosing Wisely Canada; 2015 Jun 2. [cited 2017 May 5]. Available from: http://www.choosingwiselycanada.org/recommendations/nuclear-medicine/

15. Emergency medicine: ten things physicians and patients should question [Internet]. Toronto: Choosing Wisely Canada; 2015 Jun 2. [cited 2017 May 5]. Available from: http://www.choosingwiselycanada.org/recommendations/emergency-medicine/

16. The Canadian Medical Imaging Inventory [Internet]. Ottawa: CADTH; 2016 Mar. [cited 2017 Jan 19]. Available from: https://www.cadth.ca/canadian-medical-imaging-inventory-2015

Appendices

Appendix 1: CADTH Survey Questions

A. Demographics and Clinical Setting

1. In which province/territory do you currently practice?
   - ☐ Alberta
   - ☐ British Columbia
   - ☐ Manitoba
   - ☐ New Brunswick
   - ☐ Newfoundland and Labrador
   - ☐ Northwest Territories
   - ☐ Nova Scotia
   - ☐ Nunavut
   - ☐ Ontario
   - ☐ Prince Edward Island
   - ☐ Quebec
   - ☐ Saskatchewan
   - ☐ Yukon

2. Please describe the centre you are representing and in which you predominantly practice (for example, teaching hospital, public health clinic, long-term care home, etc.). Please also describe the setting in which your centre is located (for example, large urban area, small town, remote area, etc.).

B. Diagnostic Strategy

3. Based on the setting you identified in Question 2, please describe how you diagnose suspected PE, including any strategies, guidelines, or shared decision making tools you might use, and who is involved in assessing patients (for example, nurses, primary care physicians, or specialists).

4. Are you aware of instances when the approach to diagnosing PE will differ depending on location within your province or territory (for example, teaching hospital, urban, rural, and remote)?
   - ☐ Yes (please describe the strategy and setting below)
   - ☐ No

5. Are you aware of instances when the approach to diagnosing PE will differ or when the usual diagnostic strategy cannot be followed? For example, might it differ depending on the type of

patient and how they present (e.g., pregnant women, patients with potential contraindications to imaging, etc.)?

☐ Yes (please describe below)

☐ No

6. Do you currently use any of the following risk stratification tools when diagnosing PE? Please select all that apply.

☐ Pulmonary Embolism Rule-Out Criteria

☐ Wells' Criteria for Pulmonary Embolism

☐ Geneva Score

☐ None of the above

☐ Other (please describe):

7. Do you have ready access (i.e., equipment is available in your centre) to the following rule-out or ancillary tests when diagnosing PE? Please select all that apply.

☐ Arterial blood gas

☐ Capnography

☐ Chest X-ray

☐ D-dimer testing

☐ Echocardiography

☐ Electrocardiography

☐ Leg compression ultrasound

☐ None of the above

☐ Other (please describe):

8. Do you have ready access (i.e., equipment is available in your centre) to the following imaging modalities when diagnosing PE? Please select all that apply.

☐ Ventilation/Perfusion scintigraphy

☐ Ventilation/Perfusion SPECT (single-photon emission computed tomography)

☐ Ventilation/Perfusion SPECT-CT

☐ CT (computerized tomography)

☐ Thoracic ultrasound

☐ MRI (magnetic resonance imaging)

☐ PET (positron emission tomography) modalities

☐ None of the above

☐ Other (please describe):

9. If you had different or more resources available would that change your strategy for diagnosing PE? What additional resources would you use and how would your approach to diagnosing PE change?

10. What are the main challenges you face in diagnosing PE? For example, please describe any issues around clinical capacity and expertise to perform testing, available machinery being used for other purposes, time constraints, or any other challenges you might face.

11. Do you currently transport patients out of your centre to diagnose suspected PE?
☐ Yes (please proceed to question 12)
☐ No (please proceed to question 13)

12. Could you please tell us more about transporting patients out of your centre so that a PE diagnosis can be made? For example, how far do you send them, how are costs covered, what patient characteristics might warrant travel, and any other related issues.

C. Permission to Contact and CADTH Environmental Scan Use

13. Would you be willing to be consulted further on this topic, either through an informal phone call or by email?
☐ Yes
☐ No

733 ## Appendix 2: Study Characteristics Table

First author, Publication year, Jurisdiction of origin	City/Town, Province or Territory	Study Objective	Data Collection Methods	Indication	Clinical Setting
Ahn, 2014[11]	London, Ontario	*"To assess the current level of knowledge and practice patterns of emergency physicians regarding radiation exposure from diagnostic imaging modalities for investigating acute pulmonary embolism (PE)."* (pg. 394)	Survey, retrospective chart review	PE	2 academic, tertiary care ED
Aranson, 2007[5]	Ottawa, Ontario	*"It was the objective of this study to determine the proportion of patients who undergo an appropriate diagnostic work-up following a D-dimer test performed to evaluate suspected PE or DVT."* (pg. 195)	Retrospective chart review	VTE	Academic, tertiary care hospital (ED and inpatient)
Ballantine, 2012[7]	Exeter, Ontario	*"The purpose of this study was to investigate the diagnostic approach for PE, time to access imaging and diagnostic utility of each modality in a rural emergency department (ED)."* (pg. 18)	Retrospective chart review	PE	Rural ED
Chen, 2015[12]	Toronto, Ontario	*"First, we sought to determine the utilization and PE diagnosis rate of CTPA among different patient age and gender groups in a tertiary academic emergency department (ED). Second, we sought to examine the inter-physician variation in CTPA use at our institution and correlate these metrics to physician characteristics including years in practice, gender, and training certification."* (pg. 222)	Retrospective chart review, review of physician characteristics	PE	Academic, tertiary care ED
Ingber, 2014[6]	Ontario	*"The objective of our study was to assess whether the introduction of a standardized clinical PTP assessment prior to ordering of D-dimer tests could reduce the use of subsequent radiologic imaging to investigate patients with suspected VTE in our ED."* (pg. 54)	Retrospective chart review	VTE	Academic, tertiary care ED
Le Roux, 2015[10]	Canada (un-specified)	*"There are currently no data available regarding current practices in nuclear medicine centers regarding the diagnosis of acute PE. In particular, little is known concerning the proportion of centers using SPECT or SPECT/CT rather than planar imaging, nor are there data regarding which criteria are currently used to interpret planar and V/Q SPECT. The aim of this study was, therefore, to assess these practices in nuclear medicine centers."* (pg. 1213)	Survey	PE	48 nuclear medicine departments
Smith, 2008[8]	Hamilton, Ontario	*"Our objectives were to measure the documentation rate of PTP for ED patients on whom a SimpliRED D-dimer was performed for suspected venous thromboembolism (VTE) and to determine if the clinical management decisions by the*	Retrospective chart review	VTE	Academic, tertiary care centre

		clinicians were in keeping with current recommendations." (pg. 520)			
Southern, 2014[9]	pan-Canadian	*"We documented the infrastructure available in hospitals and health regions across Canada for provision of optimal diagnosis and therapy for VTE disease."* (no page number)	Surveys, interviews, GIS mapping	VTE	658 acute care hospitals across 10 provinces and 3 territories
Spencer Netto, 2012[13]	Toronto, Ontario	*"All trauma patients diagnosed with PE at our institution during a two year period were retrospectively reviewed in order to describe the timing of PE and to compare the clinical characteristics and natural history of trauma patients diagnosed with PE at different time intervals after injury. In particular, the clinical characteristics of patients with incidental, immediate PE were described."* (pg. 1502 to 1503)	Retrospective chart review	PE	Academic, trauma centre

CT = computed tomography; CTPA = computed tomography pulmonary angiogram; DVT = deep vein thrombosis; ED = emergency department; GIS = geographic information systems; PE = pulmonary embolism; PTP = pretest probability; SPECT = single-photon emission computed tomography; V/Q = ventilation/perfusion; VTE = venous thromboembolism

Appendix 3: Survey Respondents – Self Identified Description

Province	Organization	Description of Centre or Practice
Manitoba	St. Boniface Hospital	Large, urban, teaching hospital
Manitoba	Diagnostic Services of Manitoba	Provides lab testing (provincial) and radiology (provincial – with the exception of Winnipeg and Brandon)
Manitoba	Winnipeg Regional Health Authority (2 respondents)	Large, urban, teaching hospital
New Brunswick	Horizon Health Diagnostic Imaging	Urban, teaching hospital
New Brunswick	Horizon Health	Rural hospital
New Brunswick	Horizon Health	Urban, teaching hospital
Ontario	The Ottawa Hospital	Large, urban, teaching hospital
PEI	Queen Elizabeth Hospital	Small teaching hospital
PEI	Health PEI	Community teaching hospital
Saskatchewan	Saskatoon Health Region	Teaching hospital
Saskatchewan	Regina Qu'Appelle Health Region	Teaching hospital

Appendix 4: Data Tables

Table 2: Responses for Risk Stratification and Pretest Probability Tools, by Jurisdiction

Province	PERC	Wells Criteria for PE	Geneva Score	Other
MB (n = 4)	0/4	1/4	0/4	Choice is clinician driven (1 response); none of the tools (2 responses)
NB* (n = 3)	0/3	0/3	0/3	Choice is clinician driven (1 response); none of the tools (1 responses)
ON (n = 1)	0	1	0	
PEI** (n = 2)	1/2	1/2	1/2	
SK (n = 2)	1/2	1/2	0/2	None of the tools (1 response)

*One respondent indicated that these questions were out of their scope of practice
**Same respondent indicated that all were used, the other indicated that the questions were out of their scope of practice
MB = Manitoba; NB = New Brunswick; ON = Ontario; PE = pulmonary embolism; PEI = Prince Edward Island; PERC = Pulmonary Embolism Rule-Out Criteria; SK = Saskatchewan

Table 3: Responses for Rule-Out and Ancillary Tests, by Jurisdiction

	Province				
Test	**MB (n = 4)**	**NB (n = 3)***	**ON (n = 1)**	**PEI (n = 2)**	**SK (n = 2)**
Arterial blood gas	3/4	2/3	1	1/2	2/2
Capnography	1/4	0/3	1	1/2	0/2
Chest X-ray	4/4	2/3	1	2/2	2/2
D-dimer	3/4	2/3	1	1/2	2/2
Echocardiography	2/4***	2/3	1	2/2**	2/2
Electrocardiography	2/4	2/3	1	2/2	2/2
Leg compression ultrasound	3/4***	2.3	1	2/2**	2/2

*NB had respondents from the perspective of a rural hospital and a large teaching hospital – these responses did not differ for this question; one respondent indicated that these questions were out of their scope of practice
**use of these tests is limited beyond regular business hours
***one respondent stated that leg ultrasound and echocardiography are not available at all centres
MB = Manitoba; NB = New Brunswick; ON = Ontario; PEI = Prince Edward Island; SK = Saskatchewan

Table 4: Responses for Imaging Modalities by Jurisdiction

	Province				
Test	**MB (n = 4)**	**NB (n = 3)***	**ON (n = 1)**	**PEI (n = 2)**	**SK (n = 2)**
V/Q scintigraphy	3/4	1/3	1	0/2	2/2
V/Q SPECT	1/4	1/3	1	1/2	0/2
V/Q SPECT-CT	0/4	1/3	1	1/2	0/2
CT	3/4	2/3**	1	2/2	2/2
Thoracic ultrasound	2/4	0/3	1	0/2	1/2
MRI	3/4	2/3**	1	1/2	1/2
PET	0/4	0/3	1	0/2	1/2

*one of the respondents indicated that these questions were out of their scope
**these modalities were available at the rural hospital in this jurisdiction
CT = computed tomography; MRI = magnetic resonance imaging; PET = positron emission tomography; SPECT = single-photon emission computed tomography; V/Q = ventilation/perfusion