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Routine use of post-bronchodilator testing in pulmonary function testing labs

Abstract

Purpose: Pulmonary function tests (PFTs), including spirometry with and without post-bronchodilator (post-BD) testing, are frequently performed in the assessment of asthma, along with other obstructive airway disorders. Multiple publications over the past 15 years have noted that one in three physician-diagnosed asthma cases are not in fact asthma. In this quality assurance project, we assess whether PFT labs in Alberta have policies on post-BD testing, as extraneous and unnecessary use of post-BD testing can lead to wasted staff and patient time and unnecessary expenses to the health care system.

Methods: We reviewed, in collaboration with the College of Physicians and Surgeons of Alberta and Alberta Medical Association, all PFT labs in the province of Alberta (hospital-based private not-for-profit [NFP] and private for-profit [FP] labs). This health policy study of PFT labs involved identifying the proportions and regional distribution of NFP and private FP labs in the province of Alberta while assessing post-BD policies. Each PFT lab was asked for their policy regarding spirometry and asthma diagnosis from May 1 to August 31, 2017.

Results: A total of 92 PFT labs were identified in Alberta, 74 of which were private FP (independent) labs, while 18 were private NFP (public) hospital-based labs. Policies were as follows: (i) post-BD policy existed (and if so routinely performed / not routinely done); (ii) no post-BD policy; and (iii) lab chose not to participate. All 18 hospital labs responded: 10 had no policy; six had a policy or algorithm; one did not perform post-BD testing (exercise testing) and one had multiple testing sites. Of the private FP labs, three had relevant policies and/or algorithm and 10 had none. No information was provided from 61 labs. Access to PFT labs in Northern Alberta was limited.

Conclusions: Lab policies surrounding post-BD testing were found to be heterogeneous in Alberta. Low response rates, despite the use of a systems approach and requests in writing and in person from FP labs, were notable. Development of a standardized policy across the province would be beneficial. Further higher-level review of the appropriateness of post-BD use in both FP and NFP PFT labs is needed.

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A pulmonary function test (PFT) includes spirometry with or without post-bronchodilator (post-BD) testing. The PFTs are performed as part of respiratory physiology assessments, which provide insight into respiratory disorders. In Alberta, PFTs are done in either Alberta Health Services (AHS) acute care facilities (hospital, private not-for-profit [NFP]), or external (non-hospital, private for-profit [FP]) PFT laboratories. Both are funded through a single payer system, through the government of Alberta. Health policies and guidelines are implemented to guide complex lab services and reduce variability between health regions. Adherence to diagnostic guidelines for spirometric testing hastens correct diagnosis, improves health and reduces cost to the Canadian single-payer system due to inappropriate overuse of emergency rooms, increased use of asthma-related inhaled medications and systemic drug therapies.

During the 1980s in Alberta, long wait times in accessing private NFP PFT services led to the emergence of private FP PFT labs, the first opening in 1983. The College of Physicians and Surgeons of Alberta (CPSA) accredits all Level 2, 3 and 4 PFT labs in the province of Alberta, while level 1 PFT labs do not require accreditation (office spirometry). Apart from the CPSA, which accredits these labs, there is no overarching body which reviews and standardizes PFT lab policies, including when to administer bronchodilator testing for the diagnosis of asthma and other respiratory disorders. Further, it is important to note that Alberta was the first province in Canada to have a province-wide health region (i.e., AHS).

Quality of health care services in both FP and NFP structures has been studied in the past. In 2009, a systematic review and meta-analysis was conducted, comparing the quality of care in FP and NFP nursing homes. Of the 82 studies that were assessed, the majority showed higher statistically significant quality in NFP nursing homes as compared to FP nursing homes [1]. These findings are consistent with other studies that further show that FP hospitals are associated with increased risk for death and increased spending rates than NFP hospitals [2-4].

Asthma is a common inflammatory disorder of the airways purported to affect three million Canadians [5-8]. Publications over the past 15 years have suggested that one in three physician-diagnosed asthma cases are not actually asthma. The time spent during the initial assessment of a patient with possible asthma, utilizing a complete history including allergy and physical examination can provide a more robust clinical pre-test likelihood for determining if a patient has asthma. We utilize PFTs to confirm our clinical pre-test likelihood [9-13]. As such, over 700,000 Canadians may be

misdiagnosed with asthma [7]. Misdiagnosis poses a public health concern as the long-term impact of “labelling” an individual with a chronic disease such as asthma includes longer-term treatment regimens which can escalate over time [11]. The secondary consequences may include long-term steroid-related osteoporosis [14], and untreated or sub-optimally treated other disorders and mental health concerns [15].

Historically, patients diagnosed with asthma report symptoms of wheezing, chest tightness and shortness of breath that vary over time. These are all perceptual manifestations of acute bronchoconstriction and can be easily reproduced in a laboratory setting using an allergen- or methacholine-challenge to the airways. Spirometry used in the presence of these symptoms is a very useful test for those with a moderate-high pre-test likelihood of asthma, based on history and active respiratory symptoms. Airflow obstruction must be present and reversible with bronchodilator medication. The latter may be absent with severe disease but improves with steroid therapy.

The PFT, as a standalone method to diagnose asthma simply when airflow obstruction is absent, is seldom useful; however, it is helpful in avoiding over-labeling when used properly [16-18]. Pulmonary function tests (i.e. spirometric criteria) must be used as a guide for asthma diagnosis, rather than a gold standard [16,25]. When there is moderate-high pre-test likelihood of asthma based on initial spirometry, the use of a beta-agonist bronchodilator in the PFT lab is useful to confirm a diagnosis of asthma and not wrongly label patients (Figure 1) [16,19]. Apart from this, airway challenge testing is sometimes required, such as methacholine challenge testing or exercise challenge testing.

In isolation, post-BD spirometric testing is nonspecific, with diagnosis resting primarily on physician confirmation [16]. Further, there is controversy regarding what constitutes ‘significant’ bronchodilator response [16].

In the present study, we assessed whether PFT labs in Alberta have policies on post-BD testing. We further attempted to determine the proportion of private FP and private NFP PFT labs in Alberta, describe such policies where possible, and determine if the CPSA policies for PFT lab accreditations in Alberta include statements on post-BD testing. We hypothesized that PFT labs in Alberta do not have consistent lab policies for post-BD testing, and as such may be leading to extraneous and unnecessary testing, which is wasteful of staff and patients’ time and adds unnecessary expenses to the health care system.

FIGURE 1. Diagnosis of asthma following a complete clinical history, detailed family history to form a clinical pre-test likelihood and further perform lab testing.

Methods

We reviewed all PFT labs in the province of Alberta from May 1, 2017 to August 31, 2017. No research ethic authorization was required as the study did not involve human participants [20]. Following a review with the Alberta Medical Association, we mailed letters to each lab director of CPSA accredited Level 2, 3 and 4 PFT labs. Each letter included a request for current policies, if available (hard copy, faxed or email), as well as the option to talk via phone or meet in person to discuss. We

further attempted to follow up by phone call and meet lab directors in person, when applicable. We subsequently met with many PFT medical directors as well as members of the CPSA who were also medical directors of PFT labs across Alberta. Inclusion criteria were all level 2, 3 and 4 PFT labs in the province of Alberta accredited by the CPSA. Exclusion criteria were all level 1 PFT labs in the province of Alberta (office spirometry).

The primary research question addressed in this study was whether there are policies in place to regulate when post-BD testing should be done. We further looked at (i) whether current CPSA policies (as of spring 2017) for PFT lab accreditation include statements about post-BD testing in Alberta, (ii) what proportion of AHS acute care facilities (hospitals, private not-for-profit) have PFT labs and (iii) what the policies of private for-profit and independent (private for-profit) PFT labs with regards to post-BD testing are.

Results

During the period of assessment (May 1, 2017– August 31, 2017), three PFT labs were closed; therefore, only 92 labs were contacted. The majority of the PFT labs in the province of Alberta were within 50 km of the two large centres, Edmonton and Calgary. Edmonton had 19 private FP labs, while Calgary had 24 private FP labs. Of the total number of accredited labs in Alberta (n=92), 17 (18%) were hospital-based facilities (AHS) (one is a level 2 multi-site satellite facility). The clear majority of PFT labs in Alberta (74/92; 80%) were outside of AHS and were thus private FP labs. Only 17 of the 106 acute care AHS hospitals in Alberta had PFT labs (albertahealthservices.ca). At the time of the study, no standardized policy was available through the lab regulatory body (CPSA).

Hospital-based PFT labs

We received information from all 18 AHS PFT labs (Figure 2); however, one lab was excluded as it performed only cardiopulmonary exercise testing and another was multi-site based. Of the included PFT labs (n=16), written policy and/or algorithms leading to a decision as to when post-BD testing should be done, were present in 10/16 (62%) of the labs. Three labs did routine bronchodilator testing, while 12 used either a policy or algorithm for determining when to administer bronchodilators. Two of the labs had no relevant policies, however performed bronchodilator testing based on a requisition form. Post-BD testing was performed routinely in only 3/16 (19%) of the labs.

FIGURE 2. Results of data collection from pulmonary function laboratories in Alberta (hospital-based pulmonary function laboratories lab policies compared with independent pulmonary function laboratories lab policies).

Independent PFT labs

There were multiple lab groups, which consisted of multiple labs in different locations, all operating under the same medical director(s) (Figure 2). Of the total of 74 independent private FP PFT labs, six lab groups did not participate ($n=39$ labs) as well as 22 other independent labs. In total, 61 labs provided no information; therefore, a significant proportion of non-hospital lab policy information was not possible to review. Of the information received ($n=13$ labs), three labs had a relevant written policy and/or algorithm, while 10 did not. Three labs did routine bronchodilator testing, while three used either a policy or algorithm for determining when to administer bronchodilators. There was no information for the remaining seven labs regarding bronchodilator testing.

Discussion

Our work provides the first comprehensive review of PFT labs in a Canadian province or territory. Our current study obtained information from all hospital private NFP PFT labs ($n=18$), but over 50% of non-hospital private FP PFT labs did not provide any information—a challenge for health systems research in the province of Alberta. Furthermore, many of these private FP labs were operating in multiple locations under a single administrative structure.

Our findings suggest that there is heterogeneity in policies surrounding post-BD testing in Alberta. In discussions with PFT lab directors, it became evident that there were differences in opinion regarding the utility of routine post-BD testing. Some labs performed routine bronchodilator testing for every patient, regardless of how many times they visited the

PFT lab. Other labs used an algorithm or flowchart, indicating when to perform a post-BD test. Further, some labs had objective criteria for when to perform post-BD testing (i.e., only if $FEV_1/FVC < 90$, etc.). These inconsistencies in testing pose a problem for uniformity of health care delivery.

Pulmonary function testing should be used only in the correct clinical context—after an appropriate history and physical examination to develop a pre-test likelihood of asthma [16]. In the diagnosis of asthma, bronchodilator response should not be used as a standalone test; rather, a moderate-high clinical pre-test likelihood should be considered first. This assessment must be formed prior to performing the PFT [16,23]. If there is a moderate-high clinical pre-test likelihood of asthma accompanied by airflow limitation, then post-BD spirometry should be the next step. There is no role for routine post-BD testing in all patients attending PFT labs, only for those with a moderate-high pre-test likelihood of asthma. Routine testing results in unnecessary costs to the healthcare system and were not considered necessary when PFT labs were initially developed.

Proposal of a standardized policy to harmonize when post-BD testing occurs in PFT labs in Alberta may provide benefit in addressing this problem. If asthma is strongly suspected (moderate-high clinical pre-test likelihood) at the time of testing along with airflow limitation, then post-bronchodilator spirometry would be useful; however, if asthma is not suspected, based on clinical pre-test likelihood, then bronchodilator testing should not be performed unless airflow obstruction is present. Further, remuneration for post-BD testing should be provided only in accordance with standardized policies.

FIGURE 3a. Distribution of pulmonary function laboratories in Alberta.

FIGURE 3b: Proportion of Alberta Health Services acute care facility pulmonary function laboratories compared with external pulmonary function laboratories labs across Alberta (separated by geographical regions). Information collected from College of Physicians and Surgeons of CPSA Pulmonary Function Laboratory list.

The Canadian Thoracic Society statements on spirometry do not currently indicate when post-BD testing should be done [24]. This provides for variability in practice, as shown in the results we obtained. The proportion of AHS acute care facilities with PFT labs in Alberta was low (<20%). In British Columbia, Saskatchewan and Ontario, there are fewer PFT labs than Alberta [21], and in the Northwest Territories there is only a single PFT lab, which is located in Stanton Territorial Hospital (Yellowknife, NT), although the overall population of the territory is low [21]. Nunavut does not have a PFT lab. Prior work by members of our group at a province-wide level, revealed the inability to quantify health administrative data related to PFT labs in the province of Alberta (for asthma

diagnostics), in part due to inability to capture information from private FP labs [22]. That study found that spirometry was billed about half as often as the asthma diagnostic codes were used in the same period [22]. Such findings raise questions about how administrative data is captured, and whether it is providing a complete picture in Alberta.

One limitation of the study was the inability to obtain a response from a large majority of private FP lab groups. Though many labs declined to provide information on their policies, many other labs did not respond to our letter and telephone calls. It is important to note the 100% response rate from NFP PFT labs, compared to the less than 50% response

rates from FP PFT labs. In future research, a validated survey method should be implemented to increase response rates.

Our study also revealed that access to PFT labs in Alberta may be difficult in some remote regions (Figure 3a). Alberta is a largely rural province, with vast areas encompassing many communities that may not have proper access to health care services. Plotting Alberta PFT labs on a map suggests that the majority of PFT labs are centred on Calgary and Edmonton, which makes sense due to the relatively large populations of those two cities. However, there are many communities, especially north of Edmonton, that do not have adequate access to PFT lab services. Many of these rural communities, which include small cities, towns and Indigenous communities, are located far distances from existing PFT services and individuals have to travel to receive necessary care. Access to respiratory services, at the very least spirometry, is essential for proper diagnosis. Currently, there is limited knowledge regarding spirometry use in such rural communities, and further work in this area may be beneficial.

Through this study, it was shown that there is considerable heterogeneity in policies surrounding post-BD testing in PFT labs across Alberta. Though many lab groups did not respond to our letters, and many more refused to participate, we were able to discern some current issues, especially those in the AHS labs. As such, it is imperative to further look into policies and protocols, in order to improve clinical standards and accurate diagnoses of asthma. The CPSA currently accredits PFT labs in Alberta and has their own requirements and criteria that each lab must meet prior to accreditation. Future work for PFT lab accreditation should focus on the addition of policies related to harmonizing lab standards for post-BD testing, which will secondarily minimize the common issue of asthma over-diagnosis. Further studies could also explore strategies to improve the accurate diagnosis of asthma by optimal and appropriate use of PFT labs in the province of Alberta.

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References

1. Comondore VR, Devereaux PJ, Zhou Q, Stone SB, Busse JW, Ravindran NC, Burns KE, Haines T, Stringer B, Cook DJ, Walter SD. Quality of care in for-profit and not-for-profit nursing homes: systematic review and meta-analysis. *BMJ*. 2009;339(4):b2732.
2. Devereaux PJ, Heels-Ansdell D, Lacchetti C, Haines T, Burns KE, Cook DJ, Ravindran N, Walter SD, McDonald H, Stone SB, Patel R. Payments for care at private for-profit and private not-for-profit hospitals: a systematic review and meta-analysis. *Can Med Assoc J*. 2004;170(12):1817-24.
3. Devereaux PJ, Choi PT, Lacchetti C, Weaver B, Schünemann HJ, Haines T, Lavis JN, Grant BJ, Haslam DR, Bhandari M, Sullivan T. A systematic review and meta-analysis of studies comparing mortality rates of private for-profit and private not-for-profit hospitals. *Can Med Assoc J*. 2002;166(11):1399-406.
4. Silverman EM, Skinner JS, Fisher ES. The association between for-profit hospital ownership and increased Medicare spending. *N Engl J Med*. 1999;341(6):420-6.
5. Global Initiative for Asthma. Global Initiative for Asthma. 2015. <http://ginasthma.org/> Accessed April 19, 2018.
6. Asthma Society of Canada. About Asthma. 2017. <http://www.asthma.ca> Accessed April 19, 2018.
7. Chen, Yue, Johansen, Helen, Thillaipalam, Satha, Sambell, Christie. Asthma. *Health Reports* 2005;16(2):43. Accessed from Statistics Canada Catalogue: www.statcan.gc.ca/pub/82-625-x/2015001/article/14179-eng.htm
8. Tsuyuki RT, Sin DD, Sharpe HM, Cowie RL, Nilsson C, Paul Man SF, Alberta Strategy to Help Manage Asthma (ASTHMA) Investigators. Management of asthma among community-based primary care physicians. *J Asthma*. 2005;42(3):163-7.
9. Lindensmith J, Morrison D, Deveau C, Hernandez P. Overdiagnosis of asthma in the community. *Can Respir J*. 2004;11(2):111-6.
10. Aaron SD, Vandemheen KL, Boulet LP, McIvor RA, FitzGerald JM, Hernandez P, Lemiere C, Sharma S, Field SK, Alvarez GG, Dales RE. Overdiagnosis of asthma in obese and nonobese adults. *Can Med Assoc J*. 2008;179(11):1121-31.
11. Aaron SD, Vandemheen KL, FitzGerald JM, Ainslie M, Gupta S, Lemière C, Field SK, McIvor RA, Hernandez P, Mayers I, Mulpuru S. Reevaluation of diagnosis in adults with physician-diagnosed asthma. *JAMA*. 2017;317(3):269-79.

12. Heffler E, Pizzimenti S, Guida G, Bucca C, Rolla G. Prevalence of over-/misdiagnosis of asthma in patients referred to an allergy clinic. *J Asthma*. 2015;52(9):931-4.
13. Pakhale S, Sumner A, Coyle D, Vandemheen K, Aaron S. (Correcting) misdiagnoses of asthma: a cost effectiveness analysis. *BMC Pulmonary Medicine* 2011;11(1):27.
14. Li P, Ghazala L, Wright E, Beach J, Morrish D, Vethanayagam D. Prevalence of osteopenia and osteoporosis in patients with moderate to severe asthma in Western Canada. *J Clin Invest*. 2015;38(1):23-30.
15. Katon WJ, Richardson L, Russo J, Lozano P, McCauley E. Quality of mental health care for youth with asthma and comorbid anxiety and depression. *Medical Care*. 2006;44(12):1064-72.
16. Gjevre JA, Hurst TS, Taylor-Gjevre RM, Cockcroft DW. The American Thoracic Society's spirometric criteria alone is inadequate in asthma diagnosis. *Can. Respir J*. 2006;13(8):433-7.
17. Dundas I, Chan EY, Bridge PD, McKenzie SA. Diagnostic accuracy of bronchodilator responsiveness in wheezy children. *Thorax*. 2005;60(1):13-6.
18. Email communications for data in preparation - Dr. Kieran Killian. July 2017.
19. McCormack MC, Enright PL. Making the diagnosis of asthma. *Respir Care*. 2008;53(5):583-92.
20. College of Physicians and Surgeons of Alberta. Pulmonary Function Laboratory – Facility Listing as of September 01, 2017.
www.cpsa.ca/FacilityListing/Accredited%20Facility%20Listing_Pulmonary.pdf. Accessed September 2, 2017.
21. Email communication with Dr. Dilini Vethanayagam and Dr. Kami Kandola (Deputy Chief Public Health Officer). May 2017.
22. Agarwal J, LaBranche J, Cohen J, de Gara C, Vethanayagam D. Failure of administrative data to guide Asthma care. *Spectrum*. 2018;1(1):1-8.
23. Pellegrino R, Viegi G, Brusasco V, Crapo RO, Burgos F, Casaburi RE, Coates A, Van Der Grinten CP, Gustafsson P, Hankinson J, Jensen R. Interpretative strategies for lung function tests. *Eur Respir J*. 2005;26(5):948-68.
24. Coates AL, Graham BL, McFadden RG, McParland C, Moosa D, Provencher S, Road J. Spirometry in primary care. *Can Respir J*. 2013;20(1):13-22.
25. Loughheed MD, Lemiere C, Ducharme FM, Licskai C, Dell SD, Rowe BH, FitzGerald M, Leigh R, Watson W, Boulet LP, Canadian Thoracic Society Asthma Clinical Assembly. Canadian Thoracic Society 2012 guideline update: diagnosis and management of asthma in preschoolers, children and adults. *Can Respir J*. 2012;19(2):127-64.