Alpha-1 antitrypsin (A1AT) deficiency targeted testing and augmentation therapy: A Canadian Thoracic Society clinical practice guideline

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Canadian Thoracic Society COPD Clinical Assembly Alpha-1 Antitrypsin Deficiency Expert Working Group


Alpha-1 antitrypsin (A1AT) deficiency occurs as a result of the inheritance of two proteinase inhibitor deficiency alleles located on chromosome 14. The normal phenotype is PI*M, while the most common deficiency protein phenotype is PI*Z. Protein phenotype PI*S is also a common deficiency phenotype and milder than PI*Z. Heterozygotes who are found to have one deficiency allele (usually PI*MZ, PI*SZ or PI*MZ) are not considered to be at markedly increased risk for the development of severe chronic obstructive pulmonary disease (COPD) (1,2), although it has been suggested that future studies that adjust for smoking and include other COPD-related phenotypes are required to conclusively determine the risk of COPD in PI*MZ heterozygotes (3). The presence of two deficiency alleles, most commonly PI*ZZ, results in significantly reduced serum levels of A1AT, and is associated with a markedly increased risk for the development of panlobular emphysema and liver disease. Severe A1AT deficiency occurs in approximately one in 1600 of the Scandinavian population (4), and in approximately one in 5000 to 5500 of the Canadian and North American populations (5).

First described in 1963 (6), A1AT deficiency predisposes individuals to the development of emphysema and COPD, which is markedly accelerated and more severe in the presence of cigarette smoking and other cofactors, both environmental and genetic (1,2). The exact prevalence of A1AT deficiency in patients diagnosed with COPD is not known, but results from small studies have provided estimates of 1% to 5% (1,2). Liver disease and the development of cirrhosis is the next most common clinical disease presentation (7) and may be a frequent cause of death in nonsmoking individuals with the PI*ZZ protein phenotype (8).

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A1AT protein phenotypes most strongly linked with pulmonary emphysema and COPD are associated with A1AT plasma levels below 11 µmol/L. The protease-antiprotease imbalance attributable to A1AT deficiency results in unopposed activity of leukocyte elastases with consequent degradation of elastin and other extracellular matrix components of the respiratory tract. These mechanisms are also believed to be stimulated by the presence of cigarette smoking alone, but the resultant development of emphysema is accelerated when tobacco smoke exposure and A1AT deficiency coexist. The administration of intermittent A1AT intravenous therapy has been demonstrated to significantly increase A1AT levels both in serum and in lung epithelial-lining fluid (bronchoalveolar lavage fluid) (9).

The Canadian Thoracic Society (CTS) previously published a position statement on A1AT deficiency in 2001 (1), which was an update of an earlier CTS Standards Statement originally developed in 1992 (10). The topic has also been examined by others (2,11,12). The update of an earlier CTS Standards Statement originally developed in 1992 (10). The present clinical practice guideline document systematically reviews the published literature in this area, and provides an evidence-based update using revised guideline development methodology (described below).

The present guideline statement presupposes that appropriate and optimal pharmacological therapies have been administered. The statement further assumes that nonpharmacological therapies, including smoking cessation, vaccinations, pulmonary rehabilitation, self-management skills, comprehensive case management and surgical therapies, have been and continue to be optimally used in the management of all COPD patients with A1AT deficiency.

TARGET POPULATION
The present clinical practice guideline provides direction on targeted testing and augmentation therapy for A1AT deficiency in COPD patients. For this purpose, patients with COPD have a forced expiratory volume in 1 s (FEV₁)/forced vital capacity (FVC) <0.7, as defined by the CTS (13,14) and by the Global Initiative for Chronic Obstructive Lung Disease (GOLD) (15). Patients with A1AT deficiency are defined as Pi*ZZ, Pi*Z(null) and Pi*(null)(null) protein phenotypes (and other rare A1AT disease-causing alleles) with documented A1AT levels below 11 µmol/L. The present clinical practice guideline does not address liver disease, necrotizing panniculitis, antineutrophil-cytoplasmic-positive vasculitis or mass screening/targeted testing of neonates.

TARGET USERS
The present document is intended for all health care professionals involved in the care of patients with COPD attributable to A1AT deficiency and in the care of respiratory patients for whom targeted testing of A1AT deficiency is being considered. They include respirologists, family physicians, internists, nurses, health care administrators and health care systems.

METHODOLOGY
Guideline development process
The CTS A1AT deficiency targeted testing and augmentation therapy clinical practice guideline was developed by a panel of representative professionals involved in the care of patients with COPD and A1AT deficiency. The overall process was coordinated by the CTS Respiratory Guideline Committee and staff, with the assistance of consultant librarian and methodology experts. The guideline was developed in accordance with the convention of the 23-item Appraisal of Guidelines Research and Evaluation (AGREE) II instrument (16). The research questions were prepared based on the Working Group’s recognition of clinical care gaps and solicited needs of the target populations. Questions were constructed in accordance with a ‘PICO’ process, taking into consideration the Problem, Intervention, Comparison and Outcomes within each research question, ensuring an appropriate and answerable question was constructed. The process enabled the development of a search strategy that outlined the types of studies, main topics and terms, inclusion and exclusion criteria used in the search, as well as suitable databases for the search.

Literature search
Based on the criteria outlined within the search strategy for each of the research questions, MEDLINE, EMBASE, the Cochrane Library, the Canadian Medical Association InfoBase and the National Guideline Clearinghouse were searched for pertinent published literature between January 1, 1980, and September 8, 2011. In addition, supplementary references of selected articles and recent review articles were also scanned by the Expert Working Group members for additional citations. Articles were selected for inclusion in the systematic review of the evidence if they were English or French articles reporting data on targeted testing of adult individuals with suspected A1AT deficiency, or of augmentation therapy among adult individuals with A1AT deficiency. In descending order of preference, minimum levels of evidence needed to inform the clinical questions were meta-analyses of randomized controlled trials (RCTs), RCTs, nonrandomized comparative studies or observational studies involving a minimum of 50 patients.

Evidence selection
An initial review of abstracts was performed to inform article selection for which the full text was required, with four Working Group members assigned to each research question. All abstracts were reviewed by two group members. Once full-text articles were retrieved, data extraction tables were used to systematically extract evidence from included/relevant full-text articles based on the predetermined inclusion and exclusion criteria supporting the research question. These tables were used to summarize and organize information (ie, study design, target population, interventions, outcomes, functional and clinical significance of findings) for formulation of recommendations and supporting narrative text. Another group member verified all evidence extracted into tables. Data extraction tables are available as online supplemental material (www.respiratoryguidelines.ca). Narrative text of key evidence and conclusions supporting recommendations were completed based on the data extracted.

Articles assessing targeted testing of adult individuals with suspected A1AT deficiency were evaluated for the following outcomes: improvement in case-finding, reduction in dyspnea, improved exercise capacity, improved activity, decreased exacerbations, decreased health care use and improved quality of life/health status. Articles assessing A1AT augmentation therapy were evaluated for the following outcomes: decreased exacerbations, improved quality of life/health status, reduction in dyspnea, improved exercise capacity, improved activity, decreased health care use, reduction in mortality, reduction in rate of lung function decline and stabilization of computed tomography (CT) scan-quantified lung density.

Formulating recommendations
Decisions regarding the strength of recommendations (Table 1) were achieved through a formal consensus process whereby Working Group members assigned to each of the research questions considered the strength of the evidence using the Grading of Recommendation Assessment, Development and Evaluation (GRADE) methodology (17). In addition, adverse effects, health benefits to patients, the burden on the patient associated with adherence to the recommendations, extent to which the evidence directly addressed the research question, and impact on morbidity, mortality and quality of life were considered (17,18). Final consensus on the recommendations by the Working Group was achieved via a distinct voting process, with agreement reported as a percentage of Working Group members. Extensive discussions were used to edit, correct and revise the document.

External expert commentary and review
Expert reviewers identified by the Working Group and the Canadian Respiratory Guidelines Committee on the basis of their clinical and methodological expertise, were invited to review the document. A draft of the clinical practice guideline was circulated to the reviewers,
feedback was gathered and relevant changes were incorporated into the document. Reviewers also used a short AGREE II (16) checklist to document their appraisal and enhance the usability of the document.

The present document, including the questions and content, will be regularly reviewed and updated to reflect the changing and growing body of evidence in this area. At a minimum, after a five-year period, the literature will be reviewed for new and compelling evidence to further inform or revise the guideline recommendations.

SECTION I

Question
Which populations are most appropriate for targeted testing of A1AT levels to improve case-finding of patients at risk of or with documented lung disease associated with A1AT deficiency?

Introduction
Targeted testing for A1AT deficiency is performed to establish diagnosis in individuals at risk for disease, to inform and provide recommendations to patients and to optimize clinical management (ie, exposure to tobacco smoke, biomass and other environmental pollutants, minimize respiratory infections, etc). It is also used to support genetic counselling of patients and family members (see Discussion).

Key evidence
A total of 1081 abstracts were initially identified by the search, of which 57 full-text articles were selected for complete review. Seven studies fully met the criteria and were selected for data extraction and utilization in the present review (Table 2). These studies assessed whether there was an increased rate of A1AT deficiency and/or abnormal lung disease associated with A1AT deficiency?

<table>
<thead>
<tr>
<th>Quality of evidence</th>
<th>Grade A</th>
<th>Well-designed randomized controlled trials with consistent and directly applicable results</th>
</tr>
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<tbody>
<tr>
<td>Grade B</td>
<td>Randomized trials with limitations including inconsistent results or major methodological weaknesses</td>
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<tr>
<td>Grade C</td>
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<tr>
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<td>Weak recommendation, with desirable effects closely balanced with undesirable effects</td>
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Adapted from references 17 and 19

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<tr>
<td>Section Topic</td>
<td>Strength of evidence</td>
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<tr>
<td>I</td>
<td>Literature search results informing recommendations, n</td>
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<tr>
<td>Which populations are most appropriate for targeted testing of A1AT levels, to improve case-finding of patients at risk of or with documented lung disease associated with A1AT deficiency?</td>
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or abnormal allele at the Pi locus compared with rates reported in the general population. A case-control database linkage study derived from two Danish registries (patients with A1AT deficiency, general population) (22) reported an increased risk for hospitalization with a diagnosis of COPD or asthma, but no increase in mortality among heterozygotes (Pi*MZ) compared with matched controls.

Four studies examined the role of targeted testing for A1AT deficiency in patients with asthma (21-24). No study found an increased frequency in severe A1AT deficiency or abnormal alleles at the Pi locus compared with rates reported in control populations. Three studies examined the role of targeted testing for A1AT deficiency in patients with bronchiectasis (21,25,26). Only one small case-control study reported a possible increased frequency of the Z allele among patients with bronchiectasis and common variable immunodeficiency (25), although radiographic evidence of bronchiectasis is often seen in patients with Pi*ZZ deficiency (27).

Well-known risk factors for lung cancer are tobacco smoking and COPD. Two hypothesis-generating studies investigated the possible role of abnormal alleles at the Pi locus as an additional risk factor for lung cancer (28,29). Preliminary findings suggested that heterozygote individuals for A1AT (Pi*MS, Pi*MZ or Pi*M1) were at increased risk for developing lung cancer, particularly squamous cell and bronchoalveolar cell types.

A longitudinal cohort study assessed the contribution of A1AT deficiency or abnormal alleles on symptoms and rate of lung function decline in New York (USA) fire department rescue workers following the World Trade Centre (WTC) collapse in 2001 (30). Mild (Pi*MZ) A1AT deficiency was associated with persistent cough and accelerated rate of FEV1 decline in the immediate four years following the WTC collapse. These findings highlight the possible anti-inflammatory role of A1AT, not only in the setting of chronic exposure to airborne pollutants such as tobacco smoke, but also following acute exposure to intense inflammatory stimuli, such as occurred after the WTC collapse.

Conclusions
Although the CTS Expert Working Group recommendations are derived from limited data, there may be benefit from early detection in selected populations including behaviour modification, optimized clinical management and enhanced genetic counselling. The age stratification is included in the recommendation because it was the only well-defined population studied. Individuals identified in the recommendations should undergo assessment of A1AT serum or plasma protein levels. However, there may be a role for testing individuals older than 65 years of age for the purpose of family studies and genetic counselling. In addition, it was the consensus of the Working Group that family members of individuals with documented A1AT deficiency also be offered genetic counselling and A1AT level testing, with attention devoted to siblings whose risk of A1AT deficiency is 25%.

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There was also recognition that individuals with A1AT deficiency may be misdiagnosed with asthma – the recommendations assume the correct diagnosis is established (31). In the presence of diagnostic uncertainty (for example, persistent obstruction on lung function testing) and if A1AT deficiency is a clinical diagnostic possibility, testing may be indicated. Due to the complexity of testing and interpretation of results, referral to a respiratory and/or geneticist should be considered.

**QUESTION 1**

Which populations are most appropriate for targeted testing of A1AT levels to improve case-finding of patients at risk of or with documented lung disease associated with A1AT deficiency? The following recommendations are based on evidence from seven studies and expert consensus of the CTS A1AT Deficiency Expert Working Group.

**RECOMMENDATION 1A**

We suggest targeted testing for A1AT deficiency be considered in individuals with COPD diagnosed before 65 years of age or with a smoking history of <20 pack years. (Grade of recommendation: 2C)

**RECOMMENDATION 1B**

We suggest targeted testing for A1AT deficiency not be undertaken in individuals with bronchiectasis or asthma. (Grade of recommendation: 2C)

*100% agreement was achieved for Recommendation 1A; †90% agreement was achieved for Recommendation 1B (complete agreement was not achieved because some believed there was evidence supporting targeted testing in these selected populations).

**SECTION II**

**Question**

Is A1AT augmentation therapy effective in COPD patients with documented A1AT deficiency?

**Introduction**

A1AT deficiency is a rare disease, and a permanent cure for the lung disease is not available. By administering the A1AT protein to those who are severely deficient, the belief is that progression of emphysema may be prevented or that significant improvement may occur. Previous reviews have provided discordant recommendations for the use of A1AT augmentation therapy in the clinical setting. Some have stated it is “irresponsible” to recommend the use of A1AT augmentation therapy (32, which as stated by the authors, is ‘similar’ to reference 11), while others have recommended “intravenous augmentation therapy for individuals with established airflow obstruction from AAT deficiency” (2). Predictably, this has led to confusion among health care providers regarding the use of A1AT augmentation therapy.

**Key evidence**

A total of 1399 abstracts were identified by the search, of which 41 articles were selected for complete review. Six studies fully met the criteria and 41 articles were identified by the search, of which 41 were selected for complete review. Six studies fully met the criteria and 41 articles were selected for complete review.

**Two RCTs directly examined this question. The first trial (33) randomly assigned 56 never or exsmoking subjects with A1AT deficiency (P*ZZ) and emphysema, and an FEV1 between 30% and 80% predicted, to once-monthly intravenous infusions of purified A1AT 250 mg/kg or placebo (albumin) for at least three years. The primary outcome was to compare the FEV1 rate of decline (survival was intended to be a secondary end point, but was abandoned because of insufficient data). Patients receiving augmentation therapy had significantly lower rates of lung function decline than those who did not receive augmentation therapy. The FEV1 was slower by 13.4 mL/year (95% CI 1.5 mL/year to 25.3 mL/year) among all patients receiving augmentation therapy. This effect predominantly reflected results in the subset of patients with baseline FEV1 of 30% to 65% of predicted (decline in FEV1 was slower by 17.9 mL/year; 95% CI 9.6 mL/year to 26.1 mL/year).

Although survival data with respect to augmentation therapy are limited, a large registry study (38) showed that, in patients with baseline FEV1 values <50% of predicted, significantly better survival was reported in patients receiving augmentation therapy (risk ratio = 0.64 [95% CI 0.43 to 0.94; P=0.021]). Whether patients did or did not receive augmentation therapy was not prospectively controlled and, hence, the finding may be confounded by uncontrolled factors that differed between the treated and untreated groups.

**A meta-analysis of five studies has been performed (36): one RCT (33), three nonrandomized registry groups (37-39) and an abstract.**

**Question**

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**A recent Cochrane Review (11) included RCTs that compared patients randomly assigned to A1AT augmentation therapy with controls who were randomly assigned to placebo therapy (33,34) (see above).** The primary outcomes were mortality and FEV1; secondary outcomes included exacerbations, admissions, quality of life and DLco. Randomized controlled mortality data were not available, and there were no significant differences in FEV1 rate of decline, DLco, exacerbations or quality of life. Lung density deteriorated less in the active group compared with the placebo group; the statistically significant difference was 1.14 g/L (95% CI 0.14 g/L to 2.14 g/L; P=0.03) over the course of the trials. No meaningful differences in harm from therapy were noted.

Augmentation therapy involves a purified blood product available in Canada from a single manufacturer and from a small number of commercial manufacturers worldwide; donor screening and subsequent purification, filtration and/or pasteurization processes differ among manufacturers. Reviews of adverse events do not suggest an increased...
risk of hepatitis, HIV or severe viral illnesses in treated patients. Adverse events are typically mild, and most commonly include headache, dizziness, dyspnea, fever and chills. The rate of adverse events has been estimated to be 0.02 to 0.03 events per patient per month of therapy, corresponding to two adverse events every five or more years. Adverse events account for only 3% of treatment discontinuations (12,40).

**Conclusions**

The evidence demonstrates preservation of CT scan lung density with A1AT augmentation therapy, but no significant improvement in quality of life or exacerbations. The results for FEV1 rate of decline are contradictory, with one meta-analysis, predominantly of nonrandomized registry data (36), reporting an improvement with augmentation therapy, while small RCTs (underpowered for this end point and with significant limitations) reported no significant benefit with augmentation therapy. A single registry report suggested improved mortality for severe COPD patients and A1AT deficiency after augmentation therapy (38). A summary of effectiveness end points and results with A1AT augmentation therapy is provided in Table 3.

There is ongoing debate regarding clinically meaningful end points in assessing the response to A1AT augmentation therapy. Emphysema leads to structural abnormalities of the lung that are best assessed pathologically. CT scan lung density has been shown to correlate with pathology scores in diseased lungs (41) and, may therefore, be a meaningful indicator of lung disease progression. Tanabe et al (42) undertook a two-year study of 60 COPD patients, 26 of whom experienced an exacerbation during the study. Although there were no statistically significant differences in the rate of decline in FEV1 or DLco between exacerbating and nonexacerbating COPD subjects, there was a statistically significant deterioration in CT scan lung density in COPD subjects who experienced exacerbations. In a cross-sectional study of A1AT deficient lung disease (43), CT scan lung density was shown to correlate with FEV1, airway conductance, gas-trapping, transfer factor and health status. Moreover, CT scan lung density may better predict mortality in A1AT deficiency than lung function parameters (44).

There are, however, important practical issues with using CT densitometry including lack of expertise in interpretation and lack of availability to most clinicians; multiple methods of measuring lung densitometry (ie, correcting for volume) with no yet agreed upon ideal method (45); and low inter- and intra-operator agreement regarding the extent of densitometry reduction that correlates with increasing severity of emphysema (46). It is anticipated some of these issues may be remedied by the publication of predicted lung densitometry normative values expected from ongoing lung cancer screening studies. In the interim, it is difficult to fully judge the magnitude of change in CT densitometry and its clinical significance when interpreting responses to A1AT augmentation therapies. Nonetheless, these differences have been objectively demonstrated with the use of A1AT augmentation therapy in patients with COPD attributable to A1AT deficiency.

A1AT augmentation therapy initiated as suggested in the recommendation should not routinely be discontinued if lung function deteriorates or falls below the lower FEV1 cut-off.

**TABLE 3**

Effectiveness end points and results from alpha-1 antitrypsin augmentation therapy

<table>
<thead>
<tr>
<th>End point</th>
<th>Result (quality of evidence)</th>
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<tbody>
<tr>
<td>Exacerbations</td>
<td>No evidence of benefit with augmentation therapy (Grade B)</td>
</tr>
<tr>
<td>Quality of life</td>
<td>No evidence of benefit with augmentation therapy (Grade B)</td>
</tr>
<tr>
<td>Dyspnea</td>
<td>Not studied</td>
</tr>
<tr>
<td>Exercise performance</td>
<td>Not studied</td>
</tr>
<tr>
<td>Activity limitation</td>
<td>Not studied</td>
</tr>
<tr>
<td>Health care use</td>
<td>Not studied</td>
</tr>
<tr>
<td>Mortality</td>
<td>Benefit with augmentation therapy (Grade C)</td>
</tr>
<tr>
<td>Lung function – rate of FEV1 decline</td>
<td>No evidence of benefit with augmentation therapy (Grade B)*</td>
</tr>
<tr>
<td>Radiology – CT scan lung density</td>
<td>Benefit with augmentation therapy (Grade B)*</td>
</tr>
</tbody>
</table>

*90% agreement was achieved for this recommendation (complete agreement was not achieved as some believed there was insufficient high-quality evidence to make a recommendation for or against A1AT augmentation therapy in COPD patients with A1AT deficiency).

**DISCUSSION**

This process was initiated because of the perception of a lack of consensus and understanding of appropriate patients suitable for targeted testing for A1AT deficiency, and for the use of A1AT augmentation therapy. The purpose was to provide meaningful, practical guidance for targeted testing of A1AT deficiency, and for the use of A1AT augmentation therapy. Using an evidence-based, systematic review process, led by a representative interprofessional panel of experts in the field, the present clinical practice guideline has addressed several clinically meaningful questions. The evidence from the reviews, and the experience and guidance afforded by the Expert Working Group members, enabled the formulation of relevant recommendations, fully accepting that there are significant and large gaps in the scientific literature in this area.

A summary of recommendations is provided in Table 4. The evidence supports the notion that targeted testing for A1AT deficiency be considered in individuals with COPD diagnosed before 65 years of age or with a smoking history of <20 pack years. However, there is insufficient evidence in the literature to support routine targeted testing for A1AT deficiency in individuals with bronchiectasis or asthma (if correctly distinguished from COPD). The evidence demonstrates significant slowing in the loss of CT scan lung density with A1AT augmentation therapy, but no significant improvement in quality of life or exacerbations. The results for FEV1 rate of decline are contradictory, with one meta-analysis, predominantly of nonrandomized registry data, reporting an improvement with augmentation therapy (36), while small RCTs (underpowered for the end point and with significant limitations) reporting no significant benefit with augmentation therapy (38). A single registry report suggested improved mortality for severe COPD patients (FEV1 <50%) and A1AT deficiency after augmentation therapy.

As highlighted, the present evidence-based clinical guideline statement presupposes that appropriate and optimal pharmacological as well as nonpharmacological therapies have been and continue to be used in the management of all COPD patients with A1AT deficiency (13-15,47). In this setting, it is misguided to minimize the importance...
of these foundational interventions, and it is the perception of this Working Group that such therapies are underutilized. The Working Group believed it particularly important to consider augmentation therapy only in nonsmoking or exsmoking patients with COPD (FEV₁ 25%–80% predicted) attributable to emphysema and documented A1AT deficiency (level ≤11 µmol/L), who are receiving optimal pharmacological and nonpharmacological therapies (including comprehensive case management and pulmonary rehabilitation) because of benefits in:

- Computed tomography scan lung density
- Mortality

<table>
<thead>
<tr>
<th>Recommendation</th>
<th>Suggestion</th>
<th>Grade of recommendation</th>
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<tbody>
<tr>
<td>1A</td>
<td>The Working Group suggests targeted testing for A1AT deficiency be considered in individuals with COPD diagnosed before 65 years of age or with a smoking history of &lt;20 pack years</td>
<td>2C</td>
</tr>
<tr>
<td>1B</td>
<td>The Working Group suggests targeted testing for A1AT deficiency not be undertaken in individuals with bronchiectasis or asthma</td>
<td>2C</td>
</tr>
<tr>
<td>2</td>
<td>The Working Group suggests A1AT augmentation therapy may be considered in nonsmoking or exsmoking patients with COPD (FEV₁ 25%–80% predicted) attributable to emphysema and documented A1AT deficiency (level ≤11 µmol/L), who are receiving optimal pharmacological and nonpharmacological therapies (including comprehensive case management and pulmonary rehabilitation) because of benefits in:</td>
<td>2B</td>
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A1AT augmentation therapy is currently commercially available with an intravenous A1AT protease inhibitor derived from human plasma. The drug is approved by Health Canada for treatment of patients who clinically demonstrate panlobular emphysema and have congenital deficiency of alpha-1 antiprotease (patients with Pi*ZZ, Pi*Znull or Pi*[null][null] phenotypes).

As discussed, it is challenging to completely understand the implications of improvements (ie, less reduction) in CT scan densitometry. Nonetheless, consistent and repeatable differences have been objectively demonstrated with the use of A1AT augmentation therapy in patients with COPD attributed to A1AT deficiency.

The present evidence-based guideline document did not specifically study cost-effectiveness – this has been addressed elsewhere (12). Nonetheless, the Working Group recognized the high costs associated with A1AT augmentation therapy. Clinicians and patients must fully appreciate the costs associated with A1AT augmentation therapy during deliberations regarding the appropriateness of therapy.
FUTURE RESEARCH NEEDS

It has become very apparent from this process that there is a paucity of high-quality evidence and scientific literature on this topic. Although this is a rare disease, further study is required to address several important clinical questions, and to provide further understanding and guidance for targeted testing for A1AT deficiency and A1AT augmentation therapy. It is the strong sense of the Working Group that additional small, descriptive trials of A1AT augmentation therapy will not provide further meaningful information or guidance regarding clinical efficacy. There is a pressing need for large RCTs, with long follow-up periods, assessing meaningful clinical endpoints. Such work should examine clinical effectiveness and undertake a detailed cost-analysis of A1AT augmentation therapy plus optimal usual care versus optimal usual care in A1AT-deficient COPD patients.

Advances in our understanding of the mechanisms leading to the development of emphysema and COPD in individuals with A1AT deficiency are necessary. The specific issue of early detection and potential early administration of augmentation therapy also requires additional investigation. Greater understanding of the prevalence of A1AT in selected populations is required. Acknowledging the significant current financial burden of A1AT augmentation therapy, additional work is required to explore more cost-effective means of developing and delivering therapy. These important research questions require attention to advance our understanding in this area.

KNOWLEDGE TRANSFER AND TOOLS FOR PRACTICE

In addition to publication, the present document will be posted on www.respiratoryguidelines.ca for viewing and download. A teaching and dissemination slide kit, complementing existing CTS teaching aids for the diagnosis and management of COPD, will be developed and similarly posted for viewing and download. A clinical pocket guide summarizing key recommendations and information from the present clinical practice guideline will also be developed, and be available for viewing and download (see above).

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REFERENCES

50. Sandhaus RA. Alpha-1 antitrypsin deficiency: Whom to test, whom to treat? Semin Respir Crit Care Med 2010;31:343-7.