CLINICAL PRACTICE: IMMUNOLOGY

Updating the Immunology Curriculum in Clinical Laboratory Science

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OBJECTIVE: To determine essential content areas of immunology/serology courses at the clinical laboratory technician (CLT) and clinical laboratory scientist (CLS) levels.

DESIGN: A questionnaire was designed which listed all major topics in immunology and serology. Participants were asked to place a check beside each topic covered. For an additional list of serological and immunological laboratory testing, participants were asked to indicate if each test was performed in either the didactic or clinical setting, or not performed at all.

SETTING: A national survey of 593 NAACLS approved CLT and CLS programs was conducted by mail under the auspices of ASCLS.

PARTICIPANTS: Responses were obtained from 158 programs. Respondents from all across the United States included 60 CLT programs, 48 hospital-based CLS programs, 45 university-based CLS programs, and 5 university-based combined CLT and CLS programs.

MAIN OUTCOME MEASURES: The survey was designed to enumerate major topics included in immunology and serology courses by a majority of participants at two distinct educational levels, CLT and CLS. Laboratory testing routinely performed in student laboratories as well as in the clinical setting was also determined for these two levels of practitioners.

RESULTS: Certain key topics were common to most immunology and serology courses. There were some notable differences in the depth of courses at the CLT and CLS levels. Laboratory testing associated with these courses also differed at the two levels. Testing requiring more detailed interpretation, such as antinuclear antibody patterns (ANAs), was mainly performed by CLS students only.

CONCLUSION: There are certain key topics as well as specific laboratory tests that should be included in immunology/serology courses at each of the two different educational levels to best prepare students for the workplace. Educators can use this information as a guide to plan a curriculum for such courses.

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ABBREVIATIONS: ASCLS = American Society for Clinical Laboratory Science; CLT = clinical laboratory technician; CLS = clinical laboratory scientist.

INDEX TERMS: Immunology; CLS curriculum; CLT curriculum; serology.

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The field of immunology is one of the fastest changing areas in clinical laboratory science (CLS), and as such it presents a major challenge for educators. It has been extremely difficult to determine the balance between theoretical immunological concepts and the more practical serological testing that should be presented in an introductory course in order to properly prepare students for the workplace. While many of the traditional serology tests are no longer performed in diagnostic laboratories, many automated instruments use immunological principles as the basis for testing. A survey conducted in the state of Illinois in 1987 by the Consortium for Clinical Laboratory Science Programs resulted in the development of a model immunology curriculum for the preparation of clinical laboratory science students.[1] Topics for inclusion in immunology courses were also addressed at a roundtable meeting of educators and practitioners in the field of immunology sponsored by the American Society of Clinical Pathologists in 1995. A document listing topics and laboratory testing that should be covered in immunology courses was formulated based on consensus of the group in attendance.[2] No studies on a national level have been conducted since this time, however. Due to the tremendous increase in knowledge in the field of immunology, it was determined that a new survey on a national scale that focused on actual curriculum practice would be of value to educators in the field. Therefore, a national survey of clinical laboratory scientist (CLS) and clinical laboratory technician (CLT) programs was conducted in order to determine the content areas that are currently included in most serology and immunology courses and are considered most essential for clinical laboratory science students at these two educational levels.

METHODS AND MATERIALS

Survey procedure

The survey was undertaken as a project of the Immunology/Immunohematology Scientific Assembly of the American Society for Clinical Laboratory Science (ASCLS). The instrument used was based on topics included in the Illinois study and updated by consulting current immunology and serology textbooks. The form was piloted by sending it to educators in the Immunology/Immunohematology Scientific Assembly. Their comments were compiled and the survey form modified accordingly. Respondents were asked to identify the level of their program (CLT or CLS), whether it was university or hospital-based, and if immunology and serology were presented as two separate courses or if they were combined. They also indicated the time span plus the contact hours per week students spent in the course. Other background questions included determining prerequisites and textbooks used. The main body of the survey listed major subject headings with subtopics under each. Participants were asked to check each topic covered in their course(s). A separate section was designed for serological/immunological testing. Common laboratory tests were listed and participants were asked to indicate if the procedure was performed in a didactic setting, in the clinical laboratory, or only discussed in the classroom.

ASCLS included the immunology surveys in their fall mailing to the program directors of 593 NAACLS approved programs in November of 1996. One hundred and fifty-eight surveys were returned, representing a return rate of 27 %. This included returns from 60 CLT programs, 48 hospital-based CLS programs, 45 university-based CLS programs, and 5 university-based CLT and CLS combination programs. Return rates for each individual group did not vary significantly from the overall return rate, thus approximating equal representation in each group.

Data analysis

Data were analyzed using SPSSX, and descriptive statistics were run. The five university-based combination programs were excluded from the data analysis, as it was difficult to determine the topics offered at each of the two educational levels. The data were grouped into three main categories: CLT programs, university-based CLS programs, and hospital-based CLS programs.

RESULTS

Structure of immunology/serology courses

The number and percentage of respondents for each type of program are indicated in Table 1. While delivery of immunology courses varied, almost 70% of all programs offered a combination course including both serology and principles of immunology. Thus, this represented the most typical course model for both educational levels. A small percentage of programs had separate serology and immunology courses, but this occurred mainly at the CLS level. Another model for delivery included basing immunology/serology as a unit within another course. This occurred mainly at the CLT level; 11 of 60 programs reported teaching immunological principles in this manner.

Table 1. Profile of respondents

Program Type	Number Responding	Percent
CLT	60/259	23.1%
CLS	93/334	27.8%
Total	158/593	26.6%

Combined immunology/serology courses were most typically presented in either one quarter or one semester for CLT programs and one semester for 3 + 1 and 2 + 2 university-based CLS programs. Within each of these courses, however, the contact hours varied widely. If CLT programs offered a stand-alone course, it was delivered as a combination lecture/laboratory for anywhere from two to six contact hours a week. University-based 2 + 2 programs were most likely to offer a combined lecture/laboratory course with between four and six contact hours a week. In CLS 3 + 1 programs, the method of delivery varied from a three-hour lecture course in immunology alone to a six-hour lecture/laboratory combination. Hospital-based CLS programs were more likely to offer immunology in a block of several weeks time or on a less traditional schedule.

Course prerequisites

The most frequently listed prerequisites for immunology were general chemistry, indicated by more than 61% of all CLS programs and 47% of CLT programs, and general biology, mentioned by at least 64% of all CLS programs and 40% of CLT programs. Other prerequisites varied widely. Physiology was required by more than 47% of CLT and CLS programs, with the exception of hospital-based programs. CLT programs, as indicated by 55% of respondents most frequently required anatomy, while 25% or less of university-based and hospital-based CLS programs made it a requirement. Organic chemistry was mainly listed as a requirement by CLS programs (55%), as only 20% of CLT programs required this course. This also held true for microbiology, as it was required by at least 57% of all CLS programs, but only by about 32% of CLT programs. An additional prerequisite mentioned primarily by 3 + 1 CLS programs was cell biology.

Textbooks utilized

Three textbooks were the ones most widely used by all programs. At the CLT level, Turgeon, Bryant, and Stevens were each used by 27% of the programs. In CLS programs, Turgeon was used by 31% of respondents, Stevens by 27%, and Bryant by only one program. Hospital-based programs mainly used Turgeon and Stevens, 33% and 31% respectively, and Bryant was used by a few (6%). Other books used were Sheehan, Miller, Roitt, Widmann, and Abbas. Several new textbooks have been published since the time of this survey, including a second edition of Sheehan, so these may not be current figures.

Topics included by the majority of programs

Respondents were presented with a list of general topics in immunology and asked to indicate which ones were covered in their courses. These were arranged into main headings, with subtopics under each of the general headings. These results are found in Table 2 and will be briefly summarized here. Under immunity, greater than 85% of CLT and CLS curricula alike covered natural immunity, acquired immunity, phagocytosis, and factors affecting the immune response. The vast majority of programs also covered the primary and secondary lymphoid organs, characteristics of B and T cells, the nature and specificity of antigens, the structure of haptens, primary and secondary responses, and general properties of the five antibody classes. Properties of complement proteins, and the classical and alternative pathways were also included in most courses. Additionally, cell-mediated immunity including T/B cell interaction, regulation of the immune response, antigen processing, and cellular cooperation in the immune response were discussed. Types of antigen/antibody interactions, including precipitation, agglutination, enzyme immunoassay, radioimmunoassay, and fluorescent immunoassay were other topics generally discussed. Under the topic of auto-immunity, most programs included only two specific diseases, systemic lupus erythematosus and rheumatoid arthritis. Immediate hypersensitivity was covered by most programs, as well as immunodeficiency diseases. Almost all programs also addressed quality assurance. These topics included false reactions, reagent handling, sensitivity, specificity, and use of controls. Principles of instrumentation such as fluorescent microscopy and nephelometry were covered by at least 60% of courses offered by all levels of programs.

Table 2. Topics covered by more than 85% of CLT and CLS programs

Immunity
Natural immunity; acquired immunity; phagocytosis; factors affecting the immune response

Lymphoid System
Primary and secondary organs; B and T cell characteristics; NK cell characteristics

Cellular Interactions
Antigen processing; T/B cell interaction; cell cooperation; regulation of the immune response

Nature of Antigens
Specificity; antigen characteristics; haptens

Immunoglobulins
Light chains; heavy chains; constant/variable regions; characteristics of the five antibody classes

Antigen/Antibody Interaction
Affinity and avidity; precipitation; agglutination; enzyme immunoassays; fluorescent assays; radioimunoassay; neutralization

Humoral Response
Primary response; secondary response

Cell-mediated Immunity
Mechanisms; cell types; antigen recognition; cytotoxic T cells; helper T cell activation

Complement
General properties; classical pathway; alternative pathway

Autoimmunity
Rheumatoid arthritis; systemic lupus; theory of pathogenesis

Immune Disorders
Immediate hypersensitivity; immunodeficiencies

Quality Assurance
False reactions; reagent handling; sensitivity/specificity; controls

Laboratory testing common to most immunology courses

Many routine laboratory tests are performed by both CLT and CLS students in either a student laboratory or a clinical setting. Those tests common to more than 70% of all CLS and CLT programs are listed in Table 3. Most of these traditional serological tests are still routinely performed in the clinical laboratory. Examples are the rapid plasma reagin (RPR) test for syphilis, slide agglutination test for rheumatoid arthritis, heterophil test for infectious mononucleosis, pregnancy testing, rubella testing, and testing for cold agglutinins.

Table 3. Laboratory tests performed by CLS and CLT programs

Tests performed by 70% of both CLS and CLT programs:
RPR for syphilis
RA
ASO
Latex test for strep
Heterophil test for mono
Cold agglutinins
Pregnancy
Serum protein electrophoresis

Tests performed by 70% of CLS programs only:
FANA
Rubella
Hepatitis

Tests discussed but not performed

A number of more complex and expensive tests were primarily discussed but not performed by either group. Theses included the

following: the Venereal Disease Research Laboratory (VDRL), fluorescent treponemal antibody, and microhemagglutination tests for syphilis; anti-EB testing for infectious mononucleosis, radioimmunoassays, testing for antibodies as indicators of Lyme disease, Mycoplasma, or fungal infections; HLA testing, and the Western Blot for HIV antibodies. Students also did not frequently perform complement fixation, mixed lymphocyte reactions, and febrile agglutinin testing. These latter tests are no longer common in the clinical laboratory.

DISCUSSION

Differences between CLT and CLS courses

Since topics were presented as a check-off list, it was not possible to determine the extent to which depth of coverage varied. However, there were some notable differences in topics covered by courses in CLS and CLT programs. Courses for CLS students were more likely to include topics in tissue transplantation such as HLA antigens, histocompatibility, cytotoxicity assays, mixed lymphocyte reactions, donor-recipient matching, and principles of graft rejection. A significant difference was also seen in coverage of autoimmune diseases such as thyroiditis, which were more likely to be included in courses for CLS students. Additionally, topics in tumor immunology, including the role of cytotoxic T cells and activation of macrophages were also more likely to be covered in CLS courses.

Other topics addressed almost exclusively by immunology courses in CLS programs included genetic control of antibody production, suppression of the immune response, and genetic coding for antibodies. Hypersensitivity other than immediate hypersensitivity, i.e., types II, III, and IV, were more likely to be covered in immunology courses at the CLS level. Principles of automated assays as well as immunological activities and deficiencies of complement were also mainly presented to students at the CLS level. There were no significant differences in topics covered by hospital-based and university-based CLS programs.

Differences in laboratory tests performed by CLT and CLS students

CLS students were more likely than CLT students to perform certain tests in which interpretation required considerable judgement. These included the following: testing for antibody in autoimmune thyroid diseases, immunoelectrophoresis, Ouchterlony immunodiffusion tests, radial immunodiffusion, and determination of complement levels. Additionally, determination of CD4/CD8 lymphocyte ratios, flow cytometry, DNA/RNA probe testing, fluorescent anti-nuclear antibody determinations (FANA), and testing for tumor markers were more likely to be included in CLS curricula. Specific infectious disease testing such as herpes testing, testing for cytomegalovirus (CMV), testing for toxoplasmosis, and HIV antibody screening were also mainly performed by CLS students. These differences are consistent with differences in practice levels for the CLT and CLS practitioner.

Significance

There are numerous factors that influence curriculum development. Chief amongst these is the fact that a curriculum should reflect the essence of the profession and the communities that it serves.[3] In a course such as immunology, it is essential that the curriculum reflect what is current in the workplace. This includes testing that is performed and current knowledge about immunologically related disease states. However, it is not possible to prepare students for every type of testing that may be encountered at the bench. One of the constraints for educational institutions is the cost of providing kits and equipment for students to use. In most cases, it is necessary to make judgments and choose representative techniques for the students to perform. Principles of such tests can be discussed and applied to other types of tests. A good example of this is latex agglutination tests. Once the technique is learned using one type of test, it can be applied to other situations.

On the other hand, educators may choose to include certain tests that are no longer routinely performed in the clinical laboratory for sound educational reasons. One such example is the ASO titer, which may be included for students to be able to practice pipetting skills and to see an example of a neutralization reaction. Serum protein electrophoresis may be included because it demonstrates the five protein bands that are referred to in both immunology and chemistry courses. Radial immunodiffusion may be used as a means of demonstrating measurement of immunoglobulin levels.

In order to include new material and developments, however, this means letting go of material previously presented, as most courses are structured within a confined time frame. This is often difficult for educators to do. One reason is perhaps concern that material left out may appear on certification examinations. Updates from credentialing agencies help to alleviate these fears. A recent update from ASCP, for instance, listed immunoelectrophoresis, hemagglutination inhibition, radial immunodiffusion (RID), CH50 complement test, and the ASO titer as tests that will no longer be included on the Board of Registry examination.[4] Other laboratory tests recommended by the ASCP Conference as sufficient to present in theory only include the principle of the treponemal immobilization test, febrile agglutinin testing, complement testing, and complement fixation testing.[2] These tests are no longer routinely performed in the clinical laboratory but may have a historical significance.

Certain tests that are not routinely addressed in a majority of either CLT or CLS curricula include use of DNA/RNA probes, HLA testing, and testing for tumor markers. As the prevalence of such testing increases in clinical laboratories, it is important to work these into the curriculum in some manner. If it is not feasible to have students actually perform testing, the principles should be presented. This also holds true for instrumentation such as chemoluminescence, which was not addressed by a majority of programs surveyed. Other types of instrumentation including flow cytometry, spectrophotometry, and automated assays may be presented in other courses, but

if not, the principles should definitely be included in an immunology course. This is essential as more and more of the traditional serological testing is becoming automated.

It is obvious in both the classroom and the laboratory that curricular differences reflect differences in practice levels of CLT and CLS students. In the classroom setting, CLS students receive more theory about immunological phenomena such as the role of cytokines, hypersensitive states, and autoimmune disease conditions beyond obtaining a working knowledge of the immune system. While some of this information may not apply directly to the clinical setting, it is helpful in correlating other patient tests and in making a diagnosis.

In spite of the wide variety of delivery methods for serology/immunology courses, certain key topics were part of the curriculum on each of the two educational levels. This information can be helpful to new instructors in the field, as well as more experienced educators in designing an immunology curriculum that is both relevant and practical.

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