TESTCHEST®

"RESPIRATORY FLIGHT SIMULATOR"

AQAI
SIMULATION CENTER MAINZ

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RESPIRATORY FLIGHT SIMULATOR

TestChest® – the innovation of lung simulation provides a breakthrough in respiratory training.

Organis is the developer and producer of TestChest hardware and the underlying embedded software. **AQAI** is a cooperation partner of Organis and has developed software to control TestChest and to make TestChest a complete solution for learning optimized respiratory therapy for acute and chronic lung diseases.

This high-end lung simulator is the ultimate tool for basic and advanced training for anesthesiologists, intensive care physicians and nurses. For the safety of patients experiencing respiratory failure this training ist just as important as flight simulator training is to pilots: it offers training in an environment where no harm will result to trainees or passengers (patients).

- TestChest eliminates the need for animal experiments and provides a breakthrough in training.
- TestChest realistically replicates pulmonary mechanics, gas exchange and hemodynamic responses.
- TestChest simulates respiration from normal spontaneous breathing to mechanically ventilated severely diseased lungs.
- TestChest is programmable and can be remotely operated to simulate in an unprecedented way the evolution of diseases as well as the recovery process.

FROM SKILLS TRAINING TO FULL-SCALE SIMULATION

This is an overview of the TestChest® family and its various options. It is possible to combine them in any way as you wish; any option can be added at any time.

	STAND-ALONE TESTCHEST	INTUBATION HEAD	LEARNING MODULE NIV	TRANSPULMONARY PRESSURE OPTION	MONITOR OPTION	COMBINATION WITH FULL-SCALE MANNEQUIN
Basic Control Software	X	X				
Advanced Software	X	X			X	X
Learning Module Artificial Respiration – Basics	X	X				
Learning Module Artificial Respiration – Advanced	X	X			X	X
Learning Module ARDS	X	X	X	X	X	X
Learning Module COPD	X	X	X		X	X
Learning Module Weaning / Muscular Fatigue	X	X	X		X	X

TESTCHEST® – CENTERPIECE OF THE "RESPIRATORY FLIGHT SIMULATOR"

Created and crafted with Swiss precision by Organis.

TestChest supports any kind of artificial respiration in anesthesia, intensive care, emergency medicine, long-term ventilation and home care. Two bellows driven by a linear motor generate volume, compliance and active breaths. Integrated airway resistors and the choice of different dead spaces complete the design. An S-shaped pressure-volume curve creates a realistic response to different forms of ventilatory support.

TestChest provides physiological time responses to therapy changes and thus guarantees an intense real-time experience.

KEY FEATURES
In contrast to mechanical lungs, TestChest has very unique features in terms of non-linear compliance, and hysteresis between in- and expiratory pressure-flow traces.

BASIC CONFIGURATION			
PARAMETER	MIN	MAX	UNIT
Functional Residual Capacity	100	4000	ml
Total Compliance	8	60	ml / hPa
Chestwall Compliance	3	200	ml / hPa
Airway Resistance	RP 5, RP 20, RP 50, RP 200		
Lower Inflection Points	0	100	hPa
Upper Inflection Points	1	100	hPa
Alveolar Pressure	−30	+75	hPa
Spontaneous Breathing Activity (p0.1)	0	15	hPa/ (100ms)
Spontaneous Respiratory Frequency	0	100	/ min

ADDITIONAL OPTIONS ADD MORE FUNCTIONS TO TESTCHEST®

O2 FINGER OPTION			
PARAMETER	MIN	MAX	UNIT
Arterial Oxygen Saturation	50	100	%
Shunt Fraction	0	97.5	%
Heart Rate	20	300	/ min
Cardiac Output	500	10000	ml / min
Heart-Lung Interactions	pulse pressure variation at 10, 20 and 30 cm H_2O		
Recruitment	Pressure limits, individual speed and time constants		

CO2 PRODUCTION OPTION			
PARAMETER	MIN	MAX	UNIT
CO_2 Production	0	600	mlSTPD / min
Dead Space	small 175 ml, medium 190 ml, large 205 ml		

TestChest uses an artificial "finger" to simulate oxygen saturation curves. Pulse amplitude can vary according to different states of intravascular filling. Heart-lung interactions are modeled in this way, supporting the latest generations of ventilators in advanced or automatic respiratory modes.

TestChest can be equipped with a mass flow controller for CO_2 production. Together with an adjustable dead space, realistic capnograms will be generated and can be shown on any CO_2 monitor.

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TESTCHEST® – BASIC CONTROL SOFTWARE

Basic Control created by AQAI is part of TestChest® and runs on any Windows PC.

TestChest is designed to have no controls except the power switch. It can therefore be placed anywhere and there is no need for any interaction with the model itself. All communication is done via standard network connections using TCP/IP. After start-up, Basic Control automatically establishes communication with TestChest. A set of standard parameters is loaded into TestChest by default, representing a fully healthy and passive lung. Indicators mean that the user is always aware of the communication status.

BASIC CONTROL FEATURES:
- Selection of preconfigured patients.
- Selection of preconfigured spontaneous breaths.
- Start of a calibration procedure.

These functions allow the immediate use of all advanced TestChest properties.
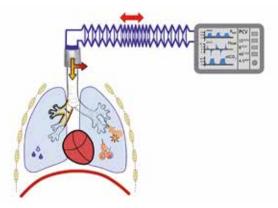
For those who want to influence the parameters directly, Basic Control can access all values that are used in the TestChest physiological model to setup the artificial lung. These include FRC, predicted FRC, overall and chest wall compliance, heart-lung interactions, nonlinearity (S-shape) of the pressure-volume loop and many more. The settings can be stored to a new patient record.

Finally, the sensors inside TestChest allow the download of measured data, e.g. intra-pulmonary pressure, intrapleural pressure, flow- or volume curves.

As an example of learning modules, AQAI adds the learning module "Artificial Respiration–Basics", which can be used within the Basic Control software, free of charge.

ADVANCED SOFTWARE

The advanced software adds look and feel to TestChest®.

A simple sweep of the mouse will highlight the various parameters that can be adjusted. Clicking on the highlighted part will open a pop-up window with a very intuitive approach to all parameters. The advanced software adds an extended physiological model to the respiratory models of TestChest, controlling circulation, metabolism, volumes, pharmacology and more. These models make it possible to take into account the whole patient and to treat him with drugs, physiotherapy, positioning etc. Clicking on the monitor opens a window where certain parameters of the respiratory and circulatory system can be shown: a full patient monitor.
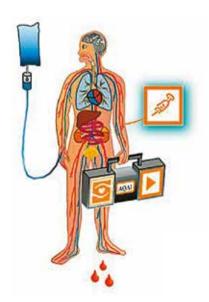
Clicking on the "radio" opens the scenario player as an integrative part of the advanced software. Scenarios consist of various stages that influence the physiological models and describe the progress of the simulated patient.

TestChest Advanced is both a preconfigured tool and a highly flexible open system: the models behind it can be accessed by experienced users and modified to create individual reactions.

All learning modules (except the module "Artificial Ventilation – Basics") make use of the advanced software and are an integrated part of it.

LEARNING MODULES – HOW TO BECOME A RESPIRATORY EXPERT

AQAI has developed several learning modules especially designed for TestChest®. The basic module, "Artificial Ventilation – Basics", is part of every TestChest®. All other learning modules use the advanced control software.

All learning modules have a standardized structure:

- AQAI TestChest Advanced Control software.
- Preprogrammed scenarios for the various tasks. The user can work through the lectures step by step or can start at a certain level. In all cases, the TestChest is preprogrammed automatically with the correct reactions. Curves can be derived from the ventilator or from the software, which will present real-time graphs of flow, volume, pressure, gas exchange parameters and more.
- PowerPoint presentations that explain the concepts of artificial ventilation. These presentations can be used to introduce a certain topic.
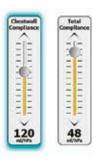- List of references.

ARTIFICIAL VENTILATION – BASICS

The module "Artificial Ventilation – Basics" is designed to show the basics of artificial ventilation.

The control mechanisms of the most common ventilators are analyzed and can immediately be used in the TestChest. This provides very intensive learning, as the novice user will be guided step by step through the world of artificial ventilation. Other topics include how to set up a ventilator, how to interpret the values and the curve patterns and how to optimize the ventilator settings to achieve stable ventilation conditions.

LEARNING OBJECTIVES
THE USER WILL BE ABLE TO …

■ understand the concepts of artificial ventilation, such as flow control, pressure control, volume control, flow trigger, pressure trigger.

■ understand compliance and resistance.

■ set up various ventilators to achieve stable ventilation conditions.

■ interpret curve traces and values derived from the ventilator.

LEARNING MODULE "ARTIFICIAL VENTILATION – ADVANCED"

This module creates a feeling of treating the patient as a whole. A number of scenarios show the more sophisticated modes of artificial ventilation and allow numerous settings to be evaluated and optimized.

LEARNING OBJECTIVES
THE USER WILL BE ABLE TO …

- understand the concept of nonlinear compliance curves, lower and upper inflection points.
- understand the concept of time constants.
- define the correct PEEP.
- understand the difference between extrinsic and intrinsic PEEP.
- understand the concepts of pressure support and mixed mandatory / spontaneous ventilation modes, such as BIPAP or APRV.
- support various kinds of spontaneous activities.
- optimize ventilator settings according to various rules: low tidal volume ventilation, avoid barotraumas, avoid atelectrauma, recognize limits of ventilation.
- interpret curve traces and values derived from the ventilator.

After having worked through this module, the user will understand all modern ventilator settings and will be able to administer the best therapy for the individual patient.

LEARNING MODULE "ARDS"

This learning module runs through a case in a timely preconfigured manner, defines a patient and progresses continuously from normal lung to ARDS and to severe ARDS.

The user will be able to "treat" the simulated patient just like in real life, adapt the ventilator settings and define other therapeutic maneuvers such as volume load, catecholamine administration and more. In the advanced section, the user is able to understand the concepts of open lung ventilation, recruitment, collapse and permissive hypercapnia. Finally, heart-lung interactions due to high-pressure ventilator settings can be experienced. This module can be used together with the NIV option (s. page 16).

LEARNING OBJECTIVES
THE USER WILL BE ABLE TO ...

- understand the concept of nonlinear compliance curves, lower and upper inflection points.
- define the correct PEEP, avoid intrinsic PEEP.
- administer protective lung ventilation and understand the concepts of ventilator induced lung injury.
- understand the concept of closing volume, recruitment, open lung and lung collapse and its effects on gas exchange as well as on heart lung interactions.
- optimize ventilator settings according to permissive hypercapnia and shall also understand any limitations of this concept.

LEARNING MODULE "COPD"

This learning module runs through a case in a timely preconfigured manner, defines a patient and progresses continuously from normal lung to COPD, to severe COPD with acute exacerbation.

The user will be able to "treat" the simulated patient just like in real life, adapt the ventilator settings, define other therapeutic maneuvers such as volume load and catecholamine administration, simulate physiotherapy and more. In the advanced section, the user is able to understand the concepts of small airway collapse, trapped air and how to support spontaneous breathing. This module can be used together with the NIV option (s. page 16).

LEARNING OBJECTIVES

THE USER WILL BE ABLE TO ...

- understand the concept of high expiratory resistance.
- optimize ventilator settings according to permissive hypercapnia and shall also understand any limitations of this concept.
- optimize the ventilator settings in view of supporting spontaneous breathing and avoiding muscular fatigue.

LEARNING MODULE "WEANING / MUSCULAR FATIGUE"

This learning module runs a case in a timely preconfigured manner, defines a patient and progresses continuously from supported spontaneous breathing into muscular fatigue.

The user will be able to "treat" the simulated patient like in real life, adapt the ventilator settings, define other therapeutic maneuvers like volume load and catecholamine administration, simulate physiotherapy and more. In the advanced part the user is able to understand the concepts of muscular training, T-piece trials and other state-of-the-art weaning concepts. This module can be used together with the NIV option (s. page 16).

LEARNING OBJECTIVES
THE USER WILL BE ABLE TO …

- understand the concepts of weaning and muscular fatigue.
- optimize the ventilator settings in view of supporting spontaneous breathing.
- understand the concept muscular training, resting periods.
- learn how to treat patients in difficult weaning situations and will use his / her knowledge in various cases. These cases will react to the treatment delivered.

TESTCHEST® MEETS MR. ANGELMAN

TestChest® can easily be connected with an intubation head "Mr. Angelman".

The combined unit can be placed below some draping to generate the feeling of a whole patient in an intensive care bed. The head allows realistic mask ventilation, placement of laryngeal airways and endotracheal intubation. Noninvasive ventilation is also possible, as various NIV masks fit perfectly to this head.

The advanced software supports the concept of physiological simulation. Besides respiratory physiology models, hemodynamic reactions and pharmacology are also among the TestChest concepts. A monitor display and a combination with the learning modules result in a full-scale feeling.

"NON-INVASIVE VENTILATION" OPTION

Various learning modules are extended by an optional addition of "Non-Invasive Ventilation":
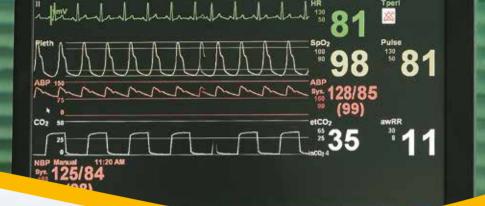- ARDS
- COPD
- Weaning / Muscular fatigue

In these three learning modules, additional scenarios support the concept of NIV, its features, advantages and limitations.

"TRANSPULMONARY PRESSURE" OPTION

TestChest provides several data channels, one of which is the actual intrapleural pressure. This data can be used to support the special concept of transpulmonary pressure in ARDS. The module contains an electropneumatic pressure generator that can be connected directly to advanced ventilators, supporting this concept as a replacement for an esophageal balloon.

The learning module adds special cases, which can be recruited with high pressure, higher than normal operations would suggest. Thanks to the concept of transpulmonary pressure, it may still be possible to recruit the patient.

INTEGRATION OF TESTCHEST® WITH FULL-SCALE MANNEQUIN

AQAI has developed an interface for certain full-scale mannequin simulators. The advanced features of TestChest® can thus replace the more basic respiratory functions inside the mannequin.
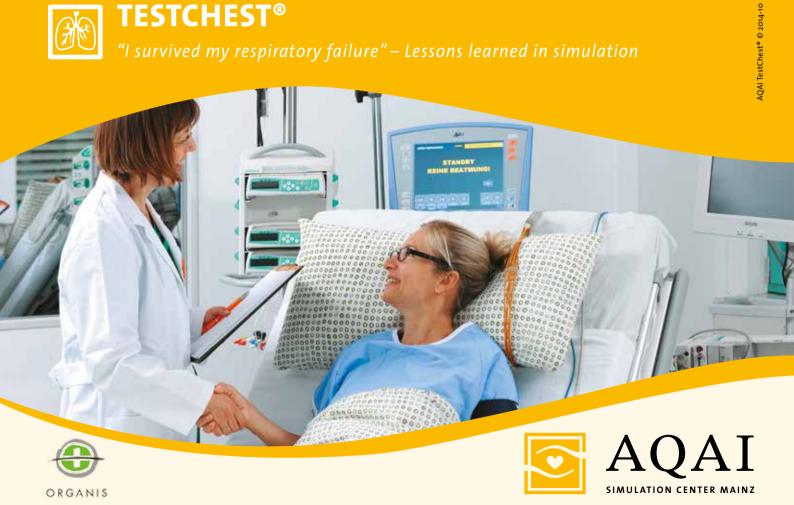

To do this, the mannequin simulator is placed on a box and TestChest below. The inner airway of the mannequin simulator is connected to the TestChest airway using a special kit. The interface software then handles the logical connection.

This combination allows full-scale simulating experiences for any kind of respiratory training courses that cannot be realized with any other simulator. Any kind of respiratory support is possible in intensive care as well as in anesthesia and emergency medicine. All common functions of the full-scale mannequin remain active, e.g. heart and breathing sounds, pulses, airway features and resuscitation.

As the advanced software adds hemodynamics and pharmacology, the functionality of the mannequin is even enhanced. The interface is constructed in such a way that the user may control the simulation from the original software of the mannequin as well as from the full graphical representation of AQAI's advanced software. This results in maximum flexibility.

TESTCHEST®

"I survived my respiratory failure" – Lessons learned in simulation

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