ECGalert

Medical device system
Doctor's User Manual

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Innovation DOOEL is the developer of the ECGalert online heart monitoring platform as a medical device system.

e. hello@ecgalert.com
w. www.ecgalert.com
t. +389 2 3109 757

Address:
11 Oktomvri 26 apt.717
1000 Skopje
Macedonia

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1. Product Description

This user manual is extension of the patient's user manual that contains the product description, intended users, indications, contraindications, clinical benefits, and performance data. It contains user requirements for use of the mobile and web applications.
The doctor can access information only to patients assigned during registration. In addition, the doctor can create new patients and upload their recorded ECG file.
The monitoring and reporting tools are explained in details with elaboration of details how to navigate, and access relevant parts for easier interpretation.
A special section is devoted to report creation with details on how to generate a report and give opinion.

1.1. Interpretation skills for doctors

The user is required to have advanced expertise in non-invasive cardiology to interpret the ECG findings. Experience in ECG monitoring software provides a significant advantage in interpreting the findings. The web-application interfaces follow the classic design principles; hence, the user needs to be averagely acquainted with such applications in order to intuitively manage the monitoring functionalities of the web application. A thorough read of the manual is recommended to make the most of the supported functionalities. The ECG findings are in accordance with the Physionet standard[1] for annotations and episodes.

1.2. Register and login

The doctor needs to be registered by the solution provider in order to gain an access to the site http://viewecg.com.
The usual login procedure with username and password is applied to enter the home page.

1.3. Maintenance, compliance, troubleshooting and cautions

These headings are explained in the patient's user manual.

[1] PhysioBank Annotations - https://www.physionet.org/physiobank/annotations.shtml

2. Data Formatting

The Physionet standard for annotations has been supplemented with additional information and beat and episode types for the purpose of meeting the necessary application requirements for data presentation.

2.1. ECG Beat Annotations

Each ECG beat annotation type has the following properties:

- Name – The full name of the ECG beat type;
- Abbreviation – An abbreviation of the full name of the ECG beat type; often used in the dashboard sections due to practical purposes;
- Sign – The sign used to represent the type of ECG beat, usually used in ECG signal charts;
- Wave – Indicates to which physiological ECG wave type the ECG beat belongs to out of the following: P, Q, R, S, T, O (Other wave type);
- Color – The color indicator for the ECG beat. The color representation helps the interpreter intuitively read the ECG beat type without paying attention to the sign. The color representation of the beats helps most while examining the list of ECG strips which are part of the monitoring page. Not all ECG beat annotations are associated with color, i.e. some of the beat annotations will have the default signal color.
- InBPM – Indicates whether the ECG beat is included in the calculation of BPM;
- InDashboard – Indicates whether statistical information of the wave type will be included in a dashboard section;
- InReport – Indicates whether statistical information of the wave type will be included in a report form;
- InVEGroup – Indicates whether the ECG beat is part of the Ventricular Ectopy (VE) group of beats;
- InSVEGroup – Indicates whether the ECG beat is part of the Supraventricular Ectopy (SVE) group of beats;

Name	Abbreviation	Sign	Wave	Color	InBPM	InDashboard	InReport	InVEGroup	InSVEGroup
Normal	Normal	N	R	blueviolet	TRUE	FALSE	FALSE	FALSE	FALSE
Premature atrial contraction	PAC	A	R	blueviolet	TRUE	TRUE	TRUE	FALSE	TRUE
Premature ventricular contraction	PVC	V	R	deeppink	TRUE	TRUE	TRUE	TRUE	FALSE
Left bundle branch block beat	LBBB	L	R	maroon	TRUE	TRUE	FALSE	FALSE	FALSE
Right bundle branch block beat	RBBB	R	R	maroon	TRUE	TRUE	FALSE	FALSE	FALSE
Bundle branch block beat (unspecified)	BBB	B	R	maroon	TRUE	TRUE	FALSE	FALSE	FALSE
Aberrated atrial premature beat	AAPB	a	R	blueviolet	TRUE	TRUE	FALSE	FALSE	TRUE
Nodal (junctional) premature beat	NPB	J	R	darkolive-green	TRUE	TRUE	FALSE	FALSE	FALSE
Supraventricular premature or ectopic beat (atrial or nodal)	SPEB	S	R	blueviolet	TRUE	TRUE	FALSE	FALSE	TRUE

Name	Abbreviation	Sign	Wave	Color	InBPM	InDashboard	InReport	InVEGroup	InSVEGroup
R-on-T premature ventricular contraction	RTPVC	r	R	maroon	TRUE	TRUE	FALSE	FALSE	FALSE
Fusion of ventricular and normal beat	FVNB	F	R	cornflower-blue	TRUE	TRUE	FALSE	TRUE	FALSE
Atrial escape beat	AEB	e	R	blueviolet	TRUE	TRUE	FALSE	FALSE	TRUE
Nodal (junctional) escape beat	NEB	j	R	darkolive-green	TRUE	TRUE	FALSE	FALSE	FALSE
Supraventricular escape beat (atrial or nodal)	SEB	n	R	blueviolet	TRUE	TRUE	FALSE	FALSE	TRUE
Ventricular escape beat	VEB	E	R	medium-purple	TRUE	TRUE	FALSE	TRUE	FALSE
Paced beat	PB	/	R	cornflower-blue	TRUE	TRUE	FALSE	FALSE	FALSE
Fusion of paced and normal beat	FPNB	f	R	cornflower-blue	TRUE	TRUE	FALSE	FALSE	FALSE
Unclassifiable beat	UB	Q	R	teal	TRUE	TRUE	FALSE	FALSE	FALSE
Beat not classified during learning	BNCDL	?	R		TRUE	FALSE	FALSE	FALSE	FALSE
Sinus Arrest (Pause)	SA Pause	P	R	red	TRUE	FALSE	FALSE	FALSE	FALSE
Start of ventricular flutter/fibrillation	VFIB Start	[	O		FALSE	FALSE	FALSE	FALSE	FALSE
End of ventricular flutter/fibrillation	VFIB End	]	O		FALSE	FALSE	FALSE	FALSE	FALSE
Ventricular flutter wave	VF Wave	!	R		TRUE	TRUE	FALSE	FALSE	FALSE
Peak of T-wave	T Wave	t	T		FALSE	FALSE	FALSE	FALSE	FALSE
Peak of P-wave	P Wave	p	P		FALSE	FALSE	FALSE	FALSE	FALSE
Isolated QRS-like artifact	QRS Artifact	I	R		FALSE	TRUE	FALSE	FALSE	FALSE
Change in signal quality	Quality Change	C	O		FALSE	FALSE	FALSE	FALSE	FALSE
Rhythm change	Rhythm Change	Y	O		FALSE	FALSE	FALSE	FALSE	FALSE
Comment annotation	Comment	Z	O		FALSE	FALSE	FALSE	FALSE	FALSE
Peak of Q-wave	Q Wave	q	Q		FALSE	FALSE	FALSE	FALSE	FALSE
Peak of S-wave	S Wave	s	S		FALSE	FALSE	FALSE	FALSE	FALSE
ST change	ST Change	o	S		FALSE	FALSE	FALSE	FALSE	FALSE
T-wave change	T Change	x	T		FALSE	FALSE	FALSE	FALSE	FALSE
Systole	Systole	z	O		FALSE	FALSE	FALSE	FALSE	FALSE
Diastole	Diastole	d	O		FALSE	FALSE	FALSE	FALSE	FALSE
Measurement annotation	Measurement Ann	O	O		FALSE	FALSE	FALSE	FALSE	FALSE
Non-conducted pacer spike	Non-conducted PB	h	R		FALSE	TRUE	FALSE	FALSE	FALSE
U-wave peak	U Wave	u	U		FALSE	FALSE	FALSE	FALSE	FALSE
Learning	Learning	l	O		FALSE	FALSE	FALSE	FALSE	FALSE
Non-conducted P-wave (blocked APB)	Blocked APB	y	P		FALSE	FALSE	FALSE	FALSE	FALSE
Waveform onset	WF Onset	W	O		FALSE	FALSE	FALSE	FALSE	FALSE
Waveform end	WF End	w	O		FALSE	FALSE	FALSE	FALSE	FALSE

Name	Abbreviation	Sign	Wave	Color	InBPM	InDashboard	InReport	InVEGroup	InSVEGroup
Micro sinus arrest (pause)	Micro SA Pause	M	R		TRUE	FALSE	FALSE	FALSE	FALSE
Micro sinus arrest (pause)	Micro SA Pause	b	R		TRUE	FALSE	FALSE	FALSE	FALSE
Unidentified	Unidentified	U	R	teal	FALSE	TRUE	FALSE	FALSE	FALSE

2.2. Detected Rhythm Episodes

Each ECG episode annotation type has the following properties:

- Name – The full name of the ECG episode;
- Abbreviation – An abbreviation of the full name of the ECG episode; often used in the dashboard sections due to practical purposes (sometimes this abbreviation is presented with preceding "(" in the ECG charts);
- Color – The color indicator for the ECG episode. The color representation helps the interpreter intuitively read the ECG episode type without paying attention to the sign. The color representation of the episodes helps most while examining the list of ECG strips which are part of the monitoring page. Not all ECG episode annotations have a color.
- InDashboard – Indicates whether statistical information of the episode type will be included in a dashboard section;
- InReport – Indicates whether statistical information of the episode type will be included in a report form;

Name	Abbreviation	Color	InDashboard	InReport
Normal	N		FALSE	FALSE
Atrial bigeminy	AB	purple	TRUE	TRUE
Atrial fibrillation	AFIB	purple	TRUE	TRUE
Atrial flutter	AFL	purple	TRUE	TRUE
Ventricular bigeminy	B	pink	TRUE	TRUE
2° heart block	BII	salmon	TRUE	TRUE
Idioventricular rhythm	IVR		TRUE	TRUE
Nodal (A-V junctional) rhythm	NOD	green	TRUE	TRUE
Paced rhythm	P	blue	TRUE	TRUE
Pre-excitation (WPW)	PREX		TRUE	TRUE
Sinus bradycardia	SBR	bisque	TRUE	TRUE
Supraventricular tachyarrhythmia	SVTA	pink	TRUE	TRUE
Ventricular trigeminy	T	pink	TRUE	TRUE
Ventricular flutter	VFL	pink	TRUE	TRUE
Ventricular tachycardia	VT	pink	TRUE	TRUE
Noise	NOISE	khaki	FALSE	FALSE
No signal	NOSIGNAL	khaki	FALSE	FALSE

3. How to use the web application as a Doctor

The doctor logs in the website http://viewecg.com and the home page is displayed.

3.1. Doctor's home page

The doctor's home page displays the "My patients" page and three menu options: "Upload files"; "Create new patient"; and "Completed reports". The "My patients" page displays a list of patients (Figure 1).

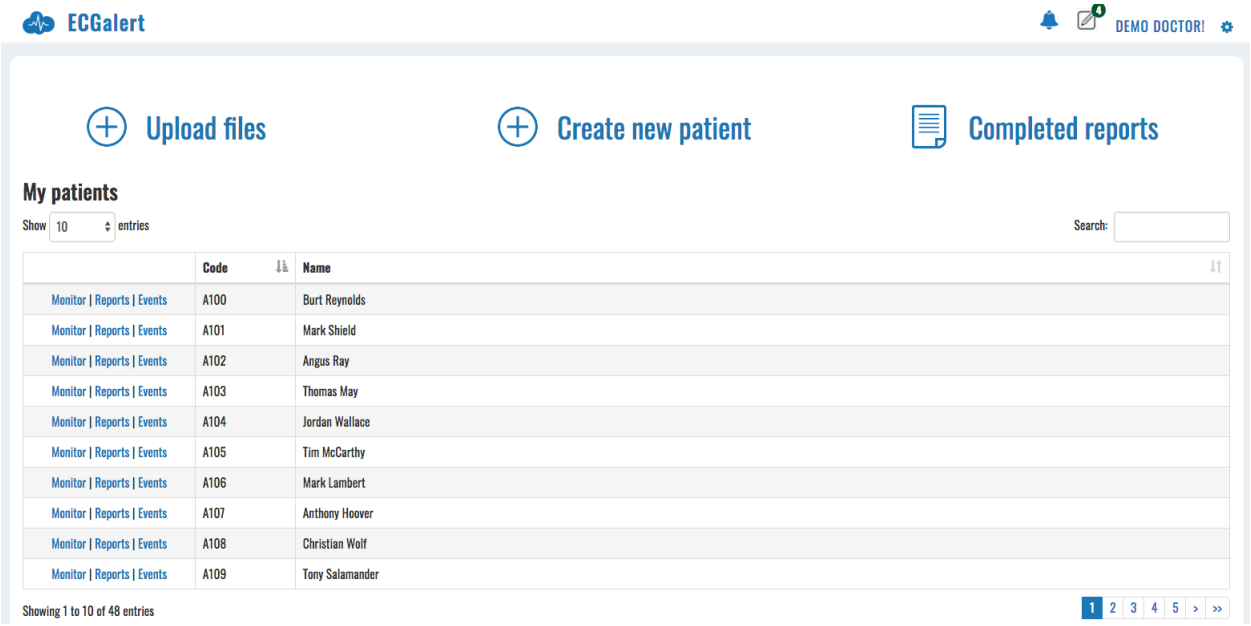

Figure 1: Doctor's home page is by default a list of patients.

My patients' page header

My patients' page displays a list of patients.
The header row contains the ECGalert logo on the top left corner. A click on this logo will always display the home page.
The right side of the header contains the notification icon, Link to draft reports, Doctor's name and settings icon.
The notification icon is link to notifications generated by the system, such as notification if the uploaded files are processed and ready to be monitored.
A link to draft reports will appear next to the alarm icon if there are any started reports that are not finished. Clicking this icon will display a list of draft reports and the doctor can choose the one to be finished.
The doctor's name is also a link to profile settings page.
A click on the settings icon displays a drop-down menu, with two options profile and log off.

List of patients

My patients' list (Figure 1) presents only 10 last patients as a default option.
You can adjust the number of patients that will be displayed in the list by clicking on the drop-down menu next to the Show message (Figure 2) below the Heading "My patients".

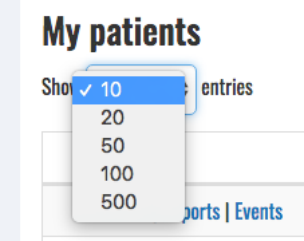

Figure 2: Selecting number of entries displayed in the list.

A search option is available on the right above the table that displays the list. You can enter a part of the patient's name and the list will be filtered showing only those patients which name contains this text.
The list is presented in a table format. Each row contains three links, code and the patient name. By default the list is sorted such that the last entered patient is enlisted on the top. You can change the sorting by clicking on the "Code" or "Name" column identifier in order to change the ordering of displayed items.
The displayed list of patients shows three links preceding the code and name of each displayed patient. These are links to specific options for each patient, including Monitoring tools, Reports, and Events. Each of these features will be explained in the corresponding sections.

Figure 3: List navigation buttons.

The next page with selected number of patients can be displayed by clicking on the consecutive page number, or on a navigation button. The displayed navigation buttons (Figure 3) can be

- << leftmost (go to top)
- < previous page
- > next page
- >> rightmost (go to bottom)

There is a notification at the bottom left corner that shows the total number of assigned patients and how many are displayed in the list.

System notifications

The alarm icon is located as the leftmost icon of the header's top right corner (Figure 4).

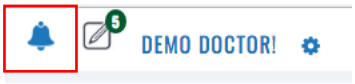

Figure 4: Alarm icon.

It is a link to system notification. If there are no system notifications, then the link is not active. If there are system notifications, then there is a number showing those system notifications that are not opened and approved by the user. A click on this icon will open a window for a system notification and enable the user to approve that the user has seen the system notification.

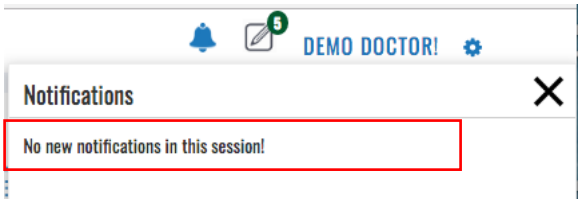

Figure 5: No new system notification.

A system notification may include a message that that there are no new notifications in the system (Figure 5), the ECG file is successfully uploaded and the corresponding processing has started, or that the processing has finished (Figure 6), so the user can monitor the uploaded ECG file.

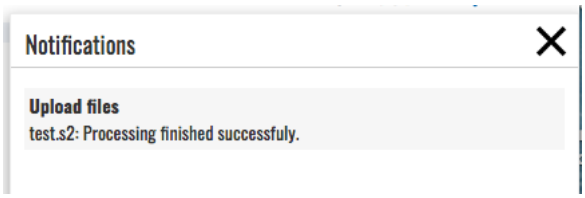

Figure 6: System notification that the processing finished and ECG is ready for monitoring.

You can close the notification window by clicking on X button at the top right corner.

Draft reports

The “Draft reports” icon is located next to the alarm icon in the header’s top right corner (Figure 7). The indicating number shows how many drafts have been started and are not completed.

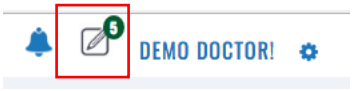

Figure 7: Draft reports' icon.

A click on the Draft report’s icon will display a list of draft reports (Figure 8) that have been started and are not completed. You can access and overview the list of draft reports by standard navigation tools as described in the “My patient’s” section, including search, selecting number of items displayed in the list, or selecting the page to be displayed if the list contains several pages.

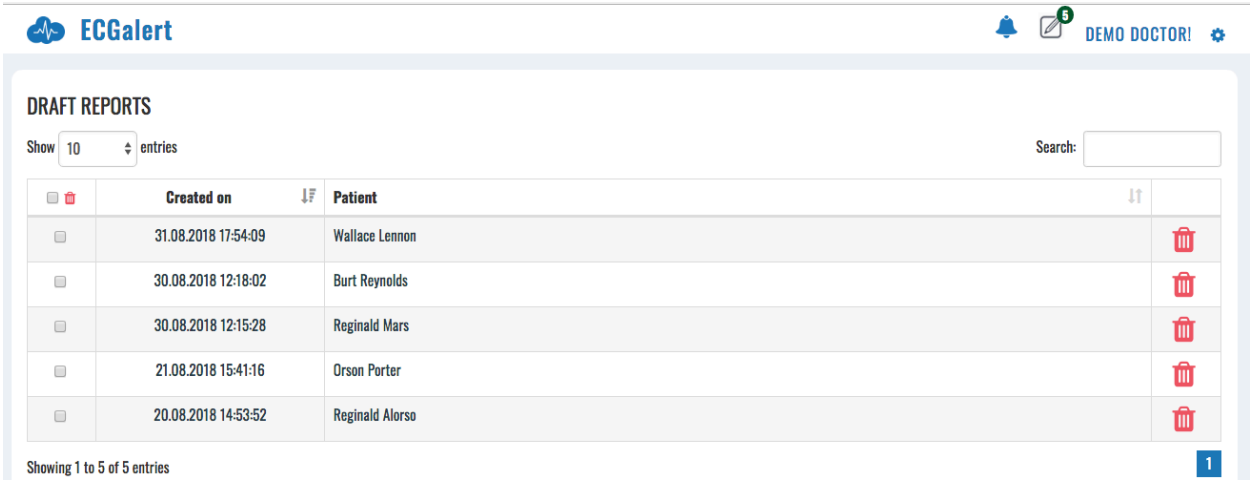

Figure 8: List of dratf reports.

Each row in the table contains a selection column, date/time stamp and patient’s name, followed by a Trash icon. A selection column enables you to select several items for deleting, while a click on a trash icon will delete only the draft report for the selected person.

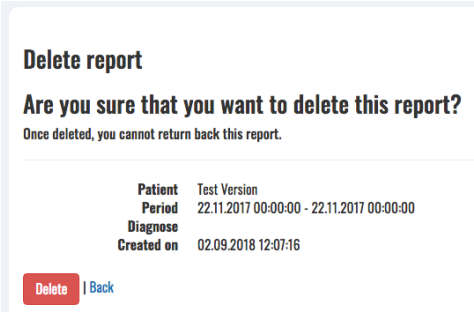

Figure 9: Confirmation of draft report deleting.

A click on a particular row in the list with patient name will continue editing the draft report for the given patient. The reporting tools are explained in the corresponding Reporting section.

Settings

A click on settings found at the top most right corner will activate the corresponding drop-down menu (Figure 10). The drop-down menu consists of profile option and log off.

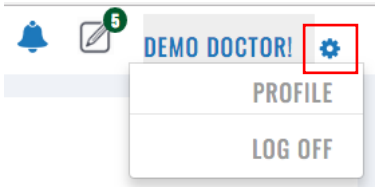

Figure 10: Settings menu options.

You can access the "profile settings" page (Figure 11) either by clicking on the name in the top right corner of the header, or by clicking the settings icon and then selecting the profile option from the drop-down menu.

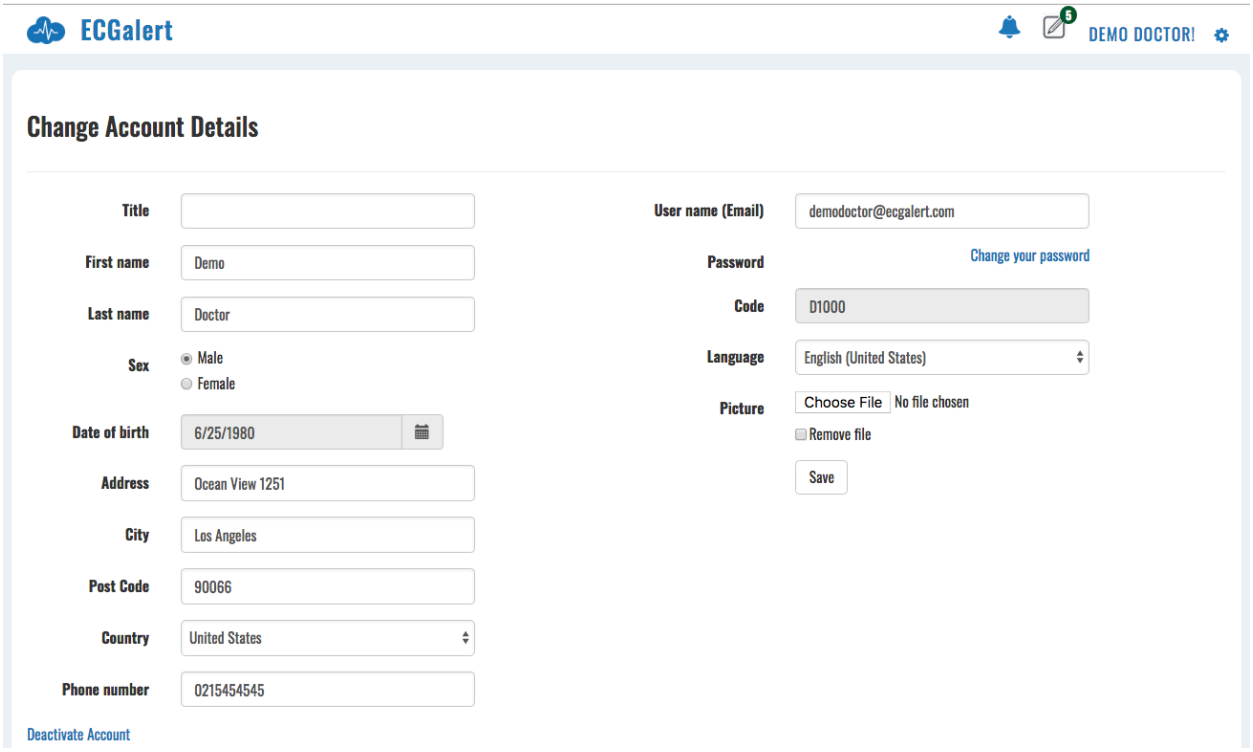

Figure 11: Profile settings page.

The doctor can change personal data, including title, first and last name, sex orientation, birth date, address, city, post code, country, phone number, username, password, language. In addition, the doctor can insert a photo or remove the existing one. Only first and last name, username and password are obligatory, the other fields are optional.

You can select an option to work as a freelancer (to give an opinion about recorded ECGs for patients.

There are two action buttons, the first one "Save" will save the changes and "Dactivate user" will deactivate the user.

3.2. Most used functions

The heading row below the header contains shortcuts to most used functions, including links to create a patient, upload ECG files and list completed reports.

Upload files

A click on menu option “Upload files” will display the Upload files form (Figure 12). You can choose a patient by the drop-down menu option, or create a new patient by a click on the corresponding link.

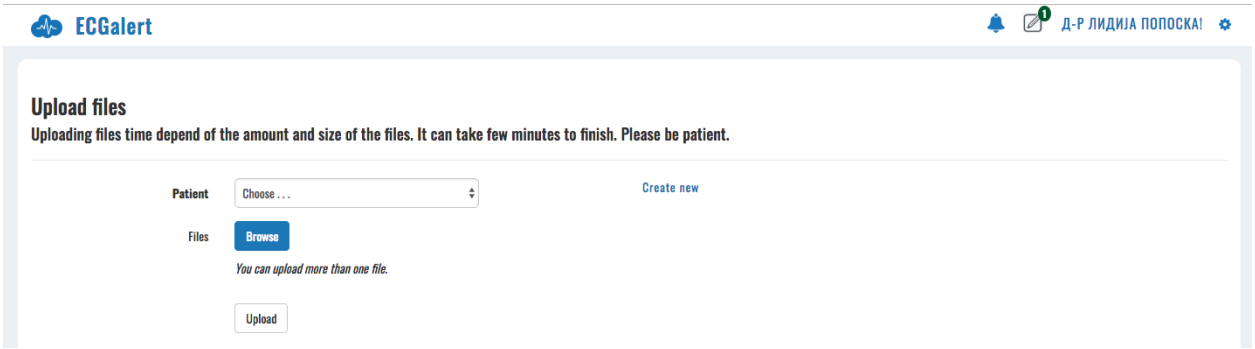

Figure 12: Upload files form.

Clicking the active button “Browse” will display a list of files from the computer operating system, where you can choose a file or several files to be uploaded.

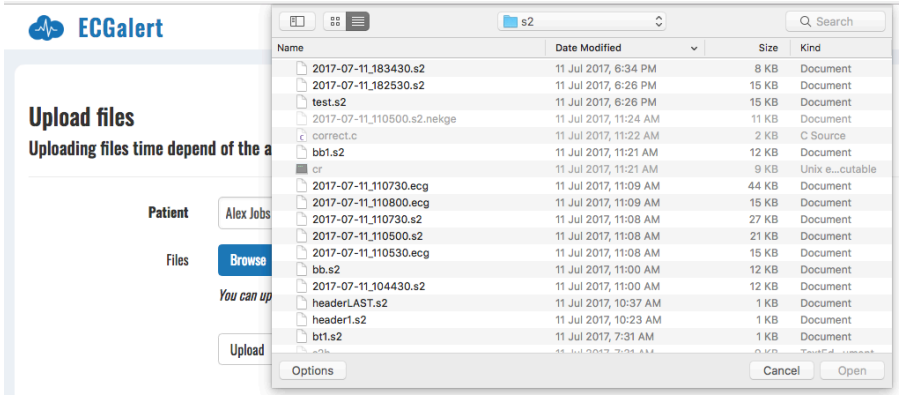

Figure 13: File browsing dialog form to select an ECG or S2 file for upload.

After selecting the files, the upload will start by clicking the action button “Upload”.
A numbered notification will appear on the notification icon, and click on it will display when the upload is finished and when the file processing is finished in order to be able to monitor recorded ECGs.

Create patient

This form (Figure 14) appears when you click on “Create patient” link as most used function in the “My patients” page. You can enter patient’s name, family name, birth date, gender, weight and height, e-mail, password, use of pacemaker, indications, medications and affiliation, as personal data. Only the name is mandatory to be entered. If patient’s email and password are entered, then the patient is able to use the patient’s monitoring page.

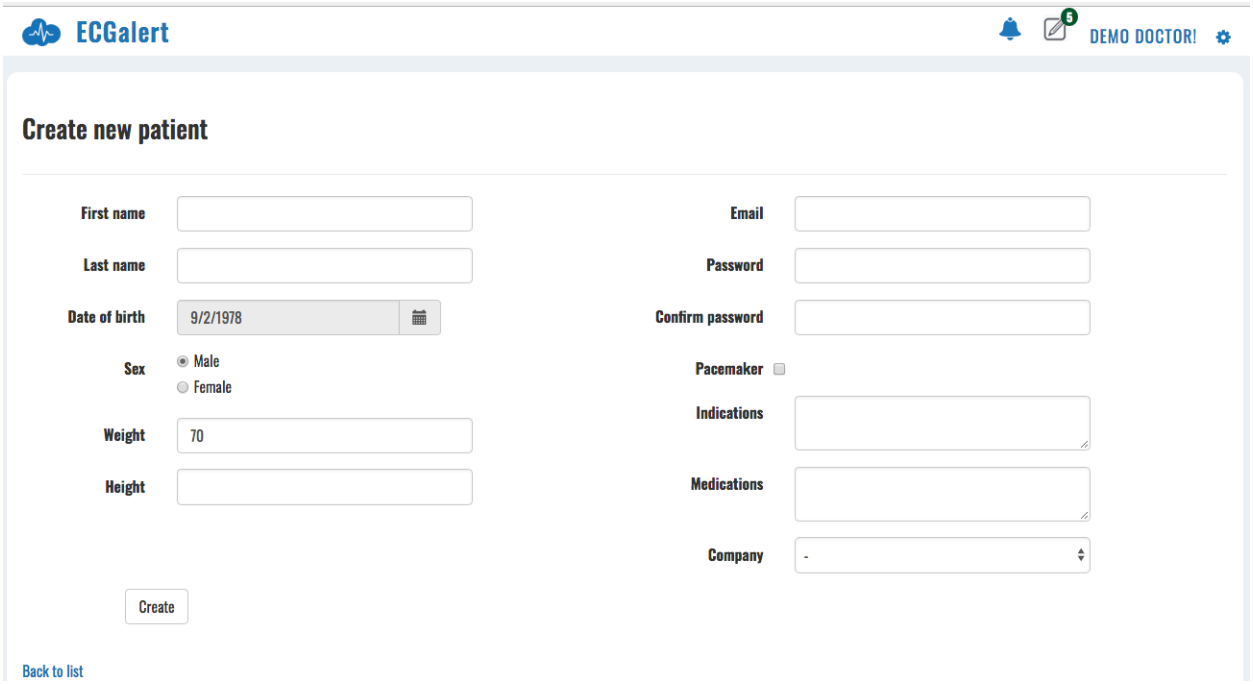

Figure 14: Create patient form.

A click on the action button “Create” will create a new record for the patient, and doctor or patient is able to upload recorded ECG files.
A click on the link “back” will go back to the list of patients or display the previous page.
If this form was invoked from the upload form, it will automatically continue processing the upload form.

Completed Reports

The list of completed reports (Figure 15) is accessed by clicking on the completed reports link on the “My patients” page.

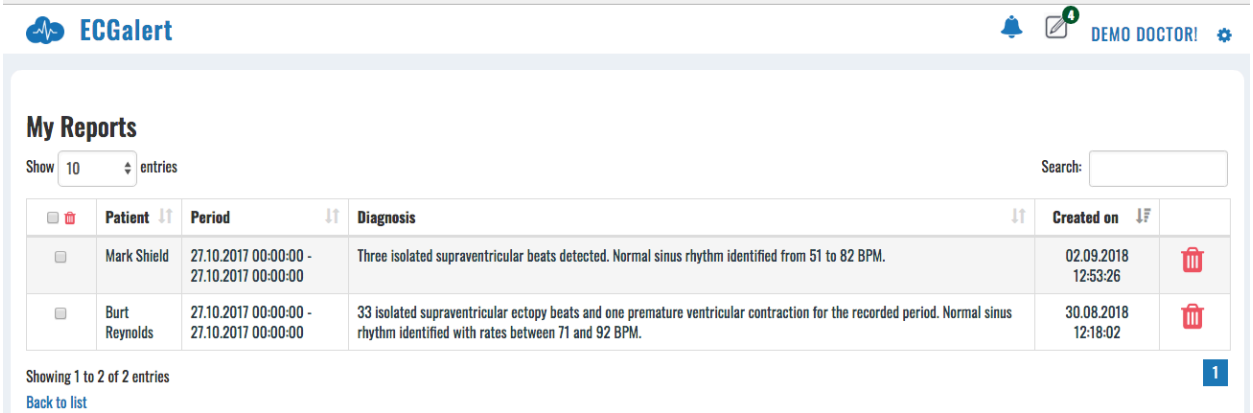

Figure 15: List of completed reports.

The list is displayed in a table that contains the following columns: selection, patient name, period, opinion, date and time stamp of creation, and trash icon. The selection column enables you to select several reports for deleting, while a click on the trash icon will delete only the report for the selected person.

You can access and overview the list of reports by standard navigation tools as described in the “My patients” section, including search, selecting number of items displayed in the list, or selecting the page to be displayed if the list contains several pages.

A click on the link “back” will go back to the list of patients or display the previous page.

Reports (Electronic Health Reports)

Reports page for a selected patient is invoked by clicking on the reports link next to the name in the “My patients” page. It is a subset of the completed reports page, since it presents a list of reports filtered to the selected user. All other elements are same.

3.3. Events

List of events

The list if events page (Figure 16) is accessible either by clicking the events link next to the patient's name in the list of the patients, or by clicking the menu option "Events", when the patient is monitored by the monitoring tool.

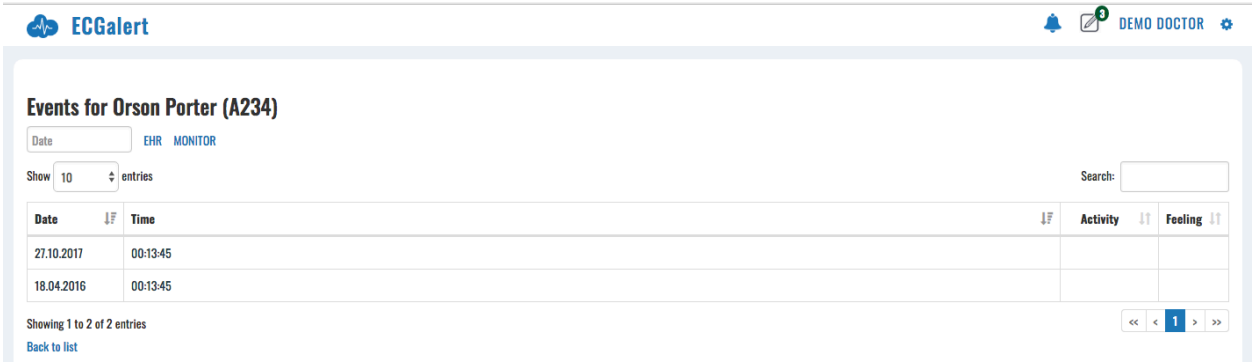

Figure 16: List of events

This is a standard list similar to the one of the patients, but it is presenting a tabular representation of the events. All functions for managing the list presentation are previously explained.

The heading displays the patient's name. The sub-heading below the heading contains a field to enter date (a click on the empty field opens a date selection dialog form, or you can enter the date in the field directly). The sub-heading contains also links to completed reports (electronic health records) for the patient.

The main part of the events page contains a list of all recorded events for the patient, sorted by their time stamp showing the latest at top. Each line displays the date and time stamps, and activity or feeling if the user has defined them while recording the event.

You can change the number of entries to be shown by clicking on the corresponding drop-down menu next to "Show entries" label. The search field is used to enter a specific date or text to search in feeling or activity field.

Navigation through the list is possible by clicking a page number or by clicking on navigation buttons for top, previous, next and last page options that correspond to <<, <, >, and >> icons.

An event details page is displayed by click on the appropriate date/time stamps on the displayed list.

Overview of an event

The events details page is used to overview a recorded event (Figure 17).
The overview contains a heading with patient's details (name, date, time and place of recording, activity and feeling when the event was recorded) and then consecutive rows of ECG strips.

Figure 17: A sample of recorded event.

Each ECG strip is displayed in a separate row on a grid with standard resolution of 25mm/cm and 1mV/cm for easier interpretation. Time duration of the ECG strip is 7.5 sec.
According to the event time duration marking, the display may contain 8 rows of ECG strips for a 60 seconds event, or 12 rows for a 90 sec event, or 16 rows for a 120 sec event. 8 rows fit in one page, and 16 rows fit in two pages.
A red colored mark is displayed in the middle to present the moment when the event was triggered. In the case of a 60 seconds event, the mark is located at the beginning of the fifth row, since the event records 30 seconds prior to event activation and 30 sec after.
There are two links at the bottom of the page, the leftmost link displays the previous event, and the rightmost the next event if any.

Printing an event

The events details page contains a printer icon. A click on printer icon invokes a dialog form to print the event (Figure 18Figure 17).
The dialog form depends on the operating system and you can select the output printer, such as the pdf output by selecting a folder and entering a name of the file).

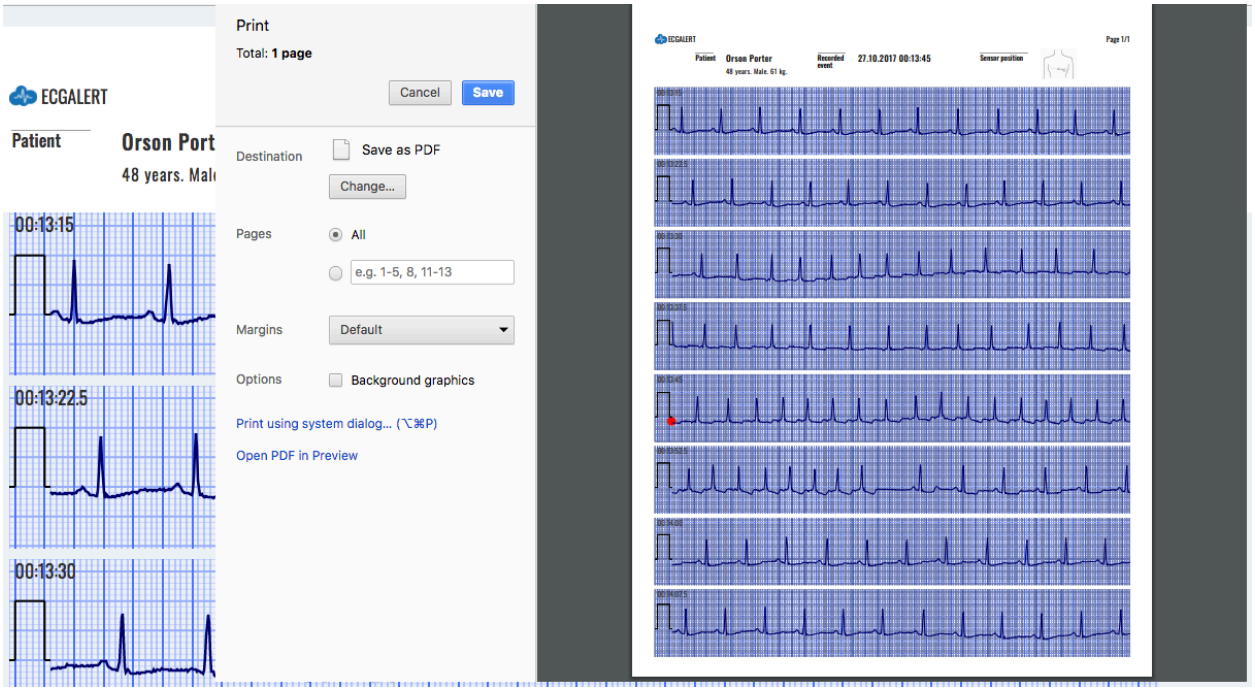

Figure 18: Dialog form to print an event.

The printed page (Figure 19) contains personal information relevant for the patient, date, time and place of recording, sensor position, and corresponding texts for activity and feeling. You can include this information to report.

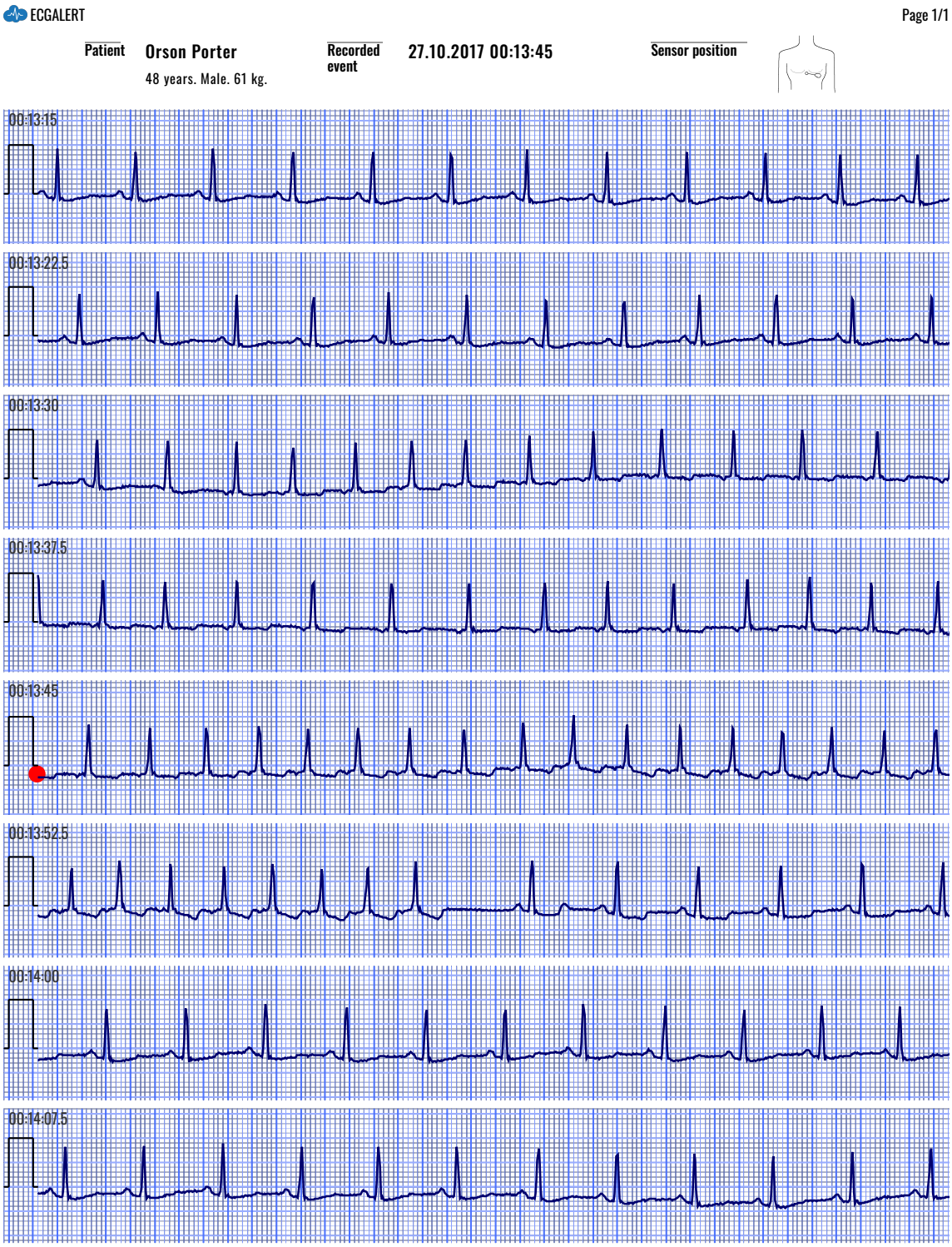

Figure 19: A pdf corresponding for recorded event.

4. How to use the monitoring tools

The monitoring tools are activated by clicking the monitor link accompanied to a patient on the doctor's home page or by clicking the monitor menu option when the doctor accesses the events or electronic health records (EHRs).

4.1. Main monitoring page

Page outlook

When the monitoring tools are invoked, the system displays the main monitoring page (Figure 20).

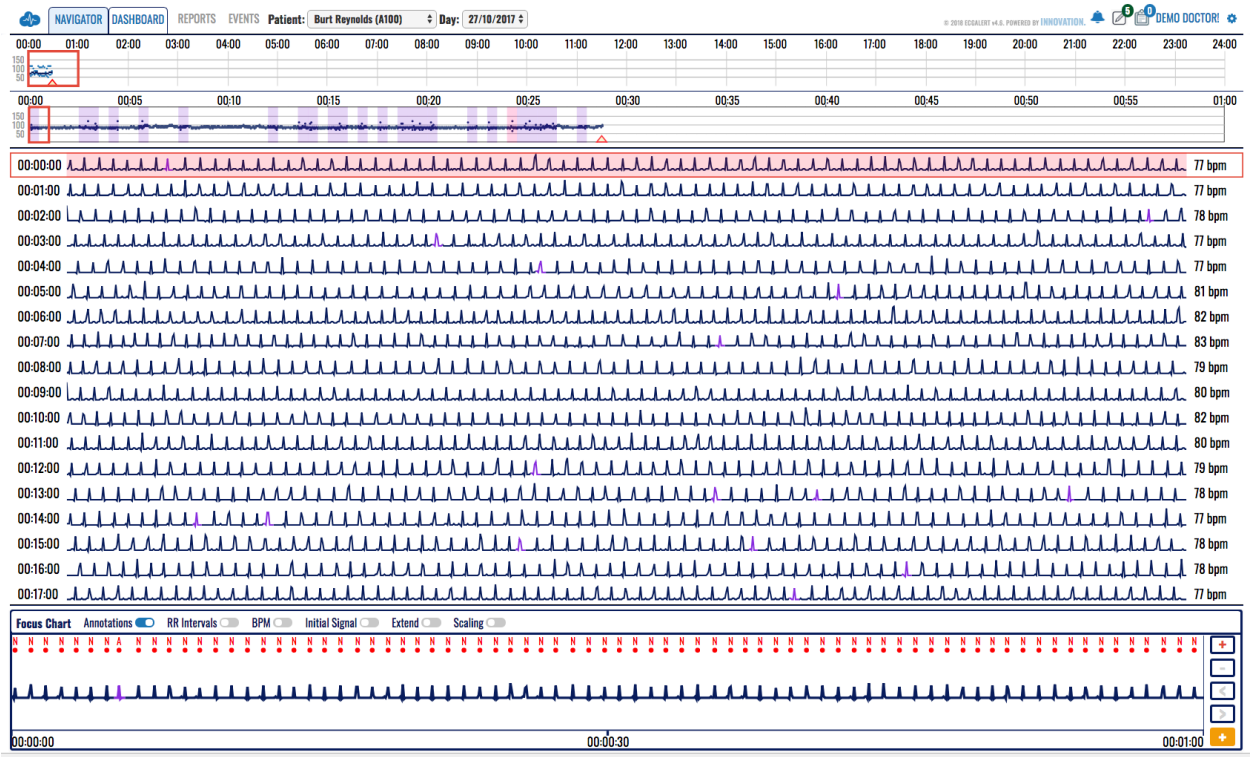

Figure 20: Main monitoring page.

It offers several functions and features enlisted in the following sections.

Basic functions

The basic monitoring tools include:

- Display of heart rate series,
- Display of dashboard info,
- Navigation through ECG strips,
- Identification of detected beat types,
- Identification of detected rhythm episodes,
- Focusing a particular ECG strip and its details,
- Adding selected ECG strips to reports,
- Analysing details on detected arrhythmia,
- Managing the system setup of the monitoring tools.

Basic graphical sections

The main monitoring page (Figure 21) is made up of five main section:

- Monitoring header,
- Heart rate or dashboard navigator,
- List of ECG strips, and
- Focus chart.

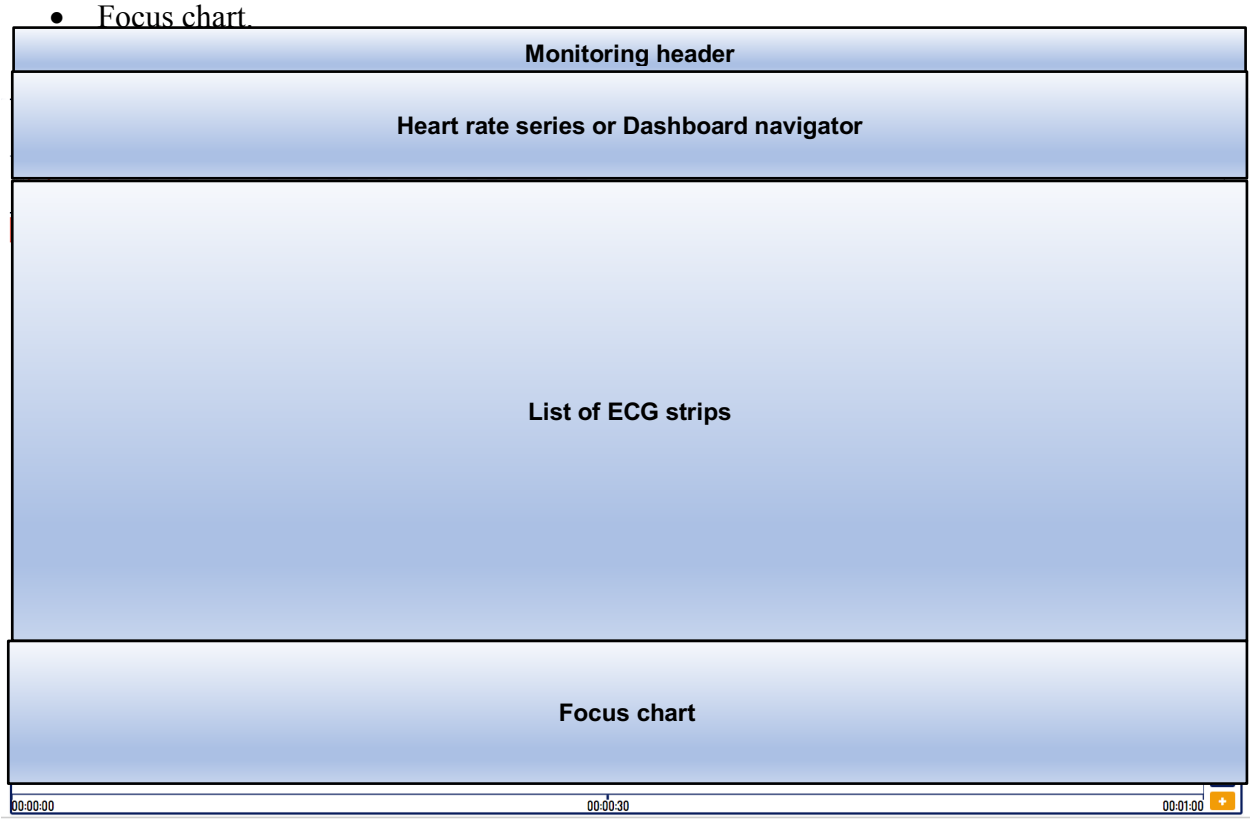

Figure 21: Main graphical sections.

The left part of the monitoring header contains links to most used functions and menu options, including toggle switch between heart rate and dashboard information for easier navigation, links to completed reports and events accompanied to the selected patient, forms to choose another patient or another date.

The right part of the monitoring header contains links to system notifications, links to draft reports that were not completed, link to the reporting tools for the accompanied patient and settings drop-down menu.

The second section displays the navigator using the time-series or dashboard information.

A list of ECG strips is displayed in the third section, along with information about calculated average BPM for the given strip.

The final section is devoted to the focus chart used to analyse details on a selected part of the ECG strip. It contains sophisticated tools for analysis of ECGs.

4.2. Monitoring header

The monitoring header replaces the standard web application header. It displays additional features and functionalities besides those in the standard application header.

Home icon

By clicking the ECGalert icon in the top leftmost corner (Figure 22), the user is redirected to the doctor's home page.

Figure 22: ECGalert icon is acting as home page link.

Navigator/Dashboard

Navigator/dashboard (Figure 23) is a toggle switch between the heart rate and dashboard navigator section. Only one can be selected.

Figure 23: Navigator/Dashboard selector.

Choose a patient

By clicking the patient's name (Figure 24), a drop-down list appears with all the patients assigned to the doctor. A click on a selected list item redirects the doctor to a monitoring page displaying the most recent record of the newly selected patient.

Figure 24: Choose a patient for monitoring.

Choose a date

By clicking on the date, a drop-down list appears displaying all days a patient has realized measurements. By changing the selected list item, the doctor is redirected to the newly selected day record.

Figure 25: Choose a date for monitoring.

System notifications

The alarm icon (Figure 4) used for system notifications is explained earlier.

4.3. Menu options and links

Menu options and links include: records used to display previously electronic health records, events to display critical moments when the patient marked the recording, report icon to

Report (Electronic Health Record)

The report link (Figure 26) is used to display a list of completed reports for the selected patient.

Figure 26: Link to completed reports (electronic health record) for the selcted patient.

Events

The event link (Figure 27) leads to a list of the events, the patient has specified while wearing the wireless sensor.

Figure 27: Link to events for the selcted patient.

All draft reports

The “Draft reports” icon, located next to the alarm icon (Figure 7) is used to display the list of draft reports for all patients. The indicating number shows how many drafts the doctor has started and not completed yet. In case there are no draft reports, the draft report icon will not be displayed.

Report icon

The report icon (Figure 28) is a link that redirects to the reporting tools for the analysed patient. The number in the top right corner of the icon indicates the number of custom ECG strips, which have been added to the current draft report session. In case there are no custom ECG strips added to the report, an indicator number will not be displayed.

Figure 28: Report icon.

Username and settings

The username and settings icon found at the top most right corner (Figure 10) are used to log OFF, change user profile information, or setup the settings for monitoring tools.

Monitoring Settings

The monitoring settings menu (Figure 29) is exclusive to the monitoring page and appears as a subsection of the settings menu. The monitoring settings menu features the following settings:

- Diagnoses radio button set: toggles the display of annotation and episode areas in the monitoring interfaces; can be either set to on or off;
- Full minute radio button set: toggles the duration of the ECG strips for the list of ECG strips section and the focus chart section; can be either set to on or off;
- Histogram scaling radio button set: toggles the scaling to either absolute or relative;
- Histogram chart type radio button set: toggles the chart type either to bar chart or line chart;
- Histogram domain radio button set: toggles the domain either to count or percent;
- Episode histogram radio button set: toggles the episode histogram information domain either to count or duration;

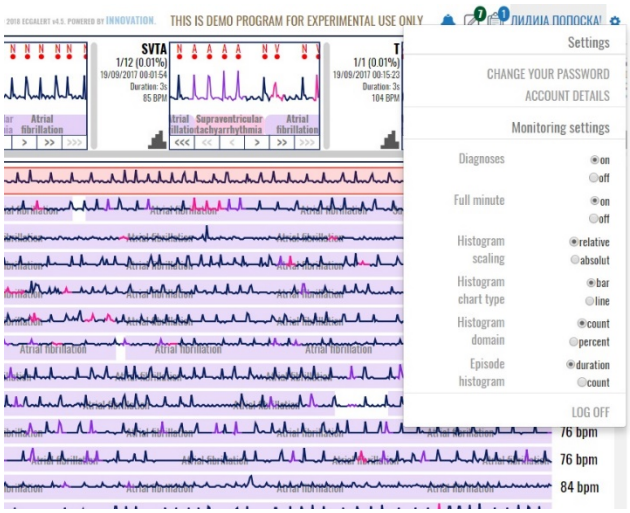

Figure 29: Settings page of the monitoring page.

4.4. Heart rate series navigator

The selector toggle switch enables to select the navigator type (heart rate series or dashboard). In a case the heart rate series navigator is selected, two navigators are displayed: the hour navigator and ECG strip selector. The heart rate navigator enables visualization of heart rate over a given time frame and easy navigation. It contains information on distribution of heart rate globally in the day (the upper part is the hour navigator) or in an hour (the lower part is the ECG strip selector).

Hour navigator

The hour heart rate series navigator (Figure 30) is divided into 24 subsections, each corresponding to one hour within the day. Time indicators clearly display the hours. Only the realized measurements are displayed, and the missing parts are empty.
A red square surrounding one of the hourly sections is used as an indicator for the current hour on display. By default, the red square is set to the first hour of realized measurement during the day.
By clicking one of the sections, the hour context is changed in accordance with the clicked section, and therefore, this navigator acts as a selector of a corresponding hour to be displayed.

Figure 30: Hour selector.

The hour navigator (selector) represents a heart rate chart. Each displayed pixel corresponds to a certain small interval in the hour navigator.
Three points are displayed for each pixel of the hour navigator, the average heart rate for the time interval corresponding to the pixel, a point drawn in a dark navy colour, and a light blue point for both the minimum and maximum rate values within the corresponding interval.
There are three horizontal lines spanning throughout the hour selector corresponding to a heart rate of 50, 100 and 150 BPM. The line values are placed on the left side of the hour selector. The total chart interval is between heart rates of 0 and 200 BPM. In the case a point on the chart exceeds the interval, it will be displayed as a 200 BPM value.
There are indicators for detected episodes represented as trapezoids aligned with the bottom of the hour selector. The fill colour corresponds with the episode colour indicator. The indicators are set to the start and end time of detected rhythm episode. In a case there is a detected episode, the mouse over shows a popup tooltip, which contains information for all the episodes present in the particular hour segment. The provided information comprises of a time stamp of the episode start and the name of the episode.

ECG strip selector

The ECG strip selector (Figure 31) displays a more detailed heart rate information for the selected hour. The length of the ECG strip can be 30 or 60 seconds, and the user can choose between ECG strips with a duration of a half or full minute via the monitoring settings section in the Settings page.

If a half minute (30 sec) ECG strips are selected, then the ECG strip selector is divided into 120 subsections, each corresponding to one half-minute (30 sec) interval within the current hour. In a case the setting is to one full minute, the granularity of the ECG strip selector sections changes to 60 selectable sections in total, one for each minute.

There are time indicators on the ECG strip selector, that is, a time indicator for each 5 minutes.

A red square surrounding one of the ECG strip selector sections is used as an indicator for the current displayed interval. By clicking on a location of interest, this interval context is changed in accordance with the clicked section.

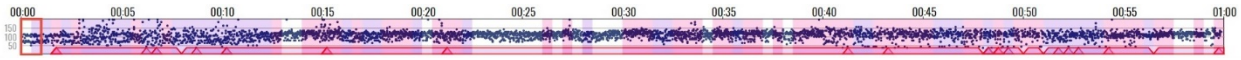

Figure 31: ECG strip selector.

The ECG strip selector represents a heart rate chart. Three points are drawn for each pixel representing a heart rate value calculated for the corresponding time interval. All these points are drawn in dark navy color.

There are three horizontal lines spanning throughout the ECG strip with heart rate values of 50, 100 and 150 BPM. The line values are displayed on the left side of the hour selector. The heart rate chart interval is between 0 and 200 BPM. In the case a point on the chart exceeds the interval, it will be displayed as a 200 BPM value.

Detected rhythm episodes are indicated by trapezoids aligned with the bottom of the ECG strip selector. The fill color of these identifiers corresponds to the rhythm episode color indicator. The indicators are temporally set to indicate the start and end of the episode.

A mouse over a particular detected rhythm episode identification results with a popup tooltip that contains information. This information comprises of a time stamp of the episode start and its rhythm identification.

The background of each ECG strip section representation is colored in accordance to the color of the present annotation in the segment. If there are multiple annotations within an ECG strip section segment, the color will match the color of the first annotation.

4.5. List of ECG strips

The main part of the monitoring tools is the list of ECG strips.

Displaying the list

The list of ECG strips (Figure 32Figure 33) contains a list of 120 ECG strips with duration of 30s or a list of 60 ECG strips with duration of 60s, in accordance with the chosen setting.
ECG strips are presented in each row of the lists. The information of the start of the ECG strip is indicated on the left, and the average heart rate on the right. Empty strips display "NaN" instead.
The displayed ECG strip is not the actual ECG signal, but a signal that is filtered using a band-pass filter in the range [0.5Hz, 30Hz] with filter length of 0.2s to eliminate the baseline drift or high frequency noise. Therefore, it is expected that the displayed strip is somehow modified version of the original recording, but an experienced doctor can notify all related arrhythmia on this signal easier than on the original recording. The focus chart is used to analyse the original signal and determine its features. These ECG strips are just fast indication for faster analysis.

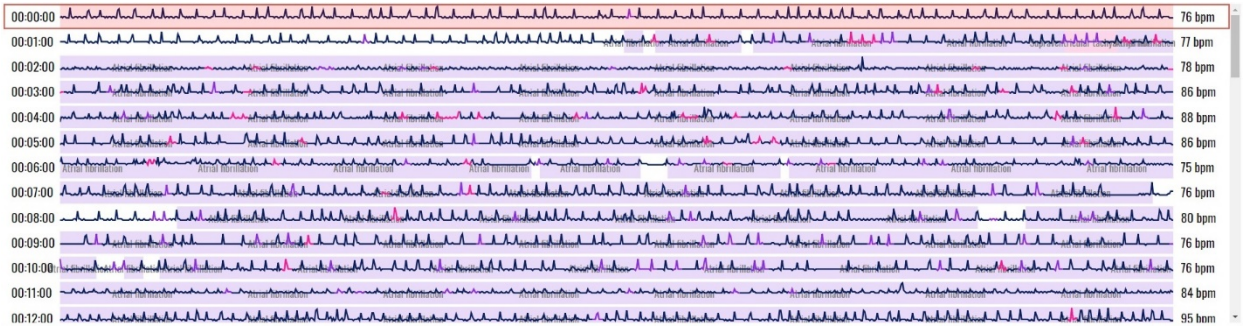

Figure 32: List of ECG strips.

One ECG strip is indicated by a red bordered rectangle around the line (Figure 33). This ECG strip is also presented in the focus chart for easier monitoring with more sophisticated tools, including analysis of RR intervals, detailed heart rate for the given ECG strip, the initial original ECG recording (unfiltered signal), grid, scaling and other features, such as zoom or navigation.
A semi-transparent rectangle is drawn behind the ECG signal, indicating the position of the ECG strip in the focus chart section. If a zoom option is used in the focus chart, then only a part of the ECG strip is marked by this semi-transparent segment.
All detected beat types are indicated in the ECG strip by a corresponding annotation color. The normal beat annotations are not marked or indicated on the ECG strip. The detected episodes are marked on the strip by drawing a semi-transparent colored rectangle, matching the area affected by the color of the rhythm episode. Discretely, the title of rhythm the episode is written on the background of these rectangles behind the displayed ECG signal to avoid any misinterpretations.
A click on a particular ECG strip will result with selecting this ECG strip, move the colored red square around it and display it in the focus chart.
A double click on a particular item in the ECG strip will be identified as a zoom option for the focus chart. This will display an ECG strip with double magnification size (2x). A consecutive double click will display a smaller ECG segment with doubled size (4x), and another click even the 8x magnification size.

Navigating the list

The doctor can navigate the list of ECG strips by the vertical slider on the right side. A mouse “drag and drop” action can be used to move the visible part of displayed ECG strips.
The vertical navigation is also possible by mouse scroll functions, so the list can be scrolled upwards or downwards.
Approaching the last visible ECG strip will load a new hour selection and the doctor can navigate as a continuous list. Similarly, approaching the first ECG strip, and scrolling upwards will load the ECG strips from previous hour.
You can also use up and down keyboard buttons to navigate through ECG strips. These actions will select previous or next ECG strip correspondingly and result to display it in the focus chart. It will also update the displayed list so the selected ECG strip is positioned in the middle of the screen.
By double clicking a certain location on the ECG strip, the magnification level increases on the focus chart and the position indicator adjust its position and size in accordance with the new magnification level. The process can be repeated until the maximum magnification level of 8 is reached. In the case of magnification, the position indicator (Figure 33) can be dragged towards left or right so that the focus chart horizontal offset is adjusted.

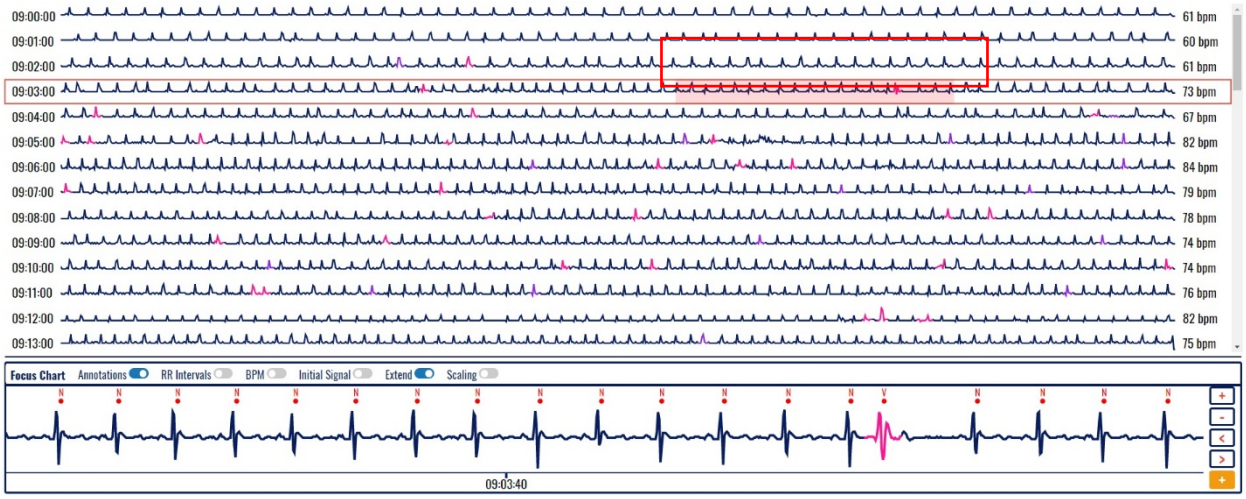

Figure 33: An ECG strip with selected segment to be displayed in the focus chart.

4.6. Focus chart

The selected ECG strip from the displayed list is presented in greater details in the Focus chart (Figure 34). The default width of the focus chart is equal to the width of the ECG strip, but it can be magnified up to 8x zoom. The last two magnification levels (4x and 8x) can display a standard grid with 10 mm/mV and 25mm/sec (Figure 35).

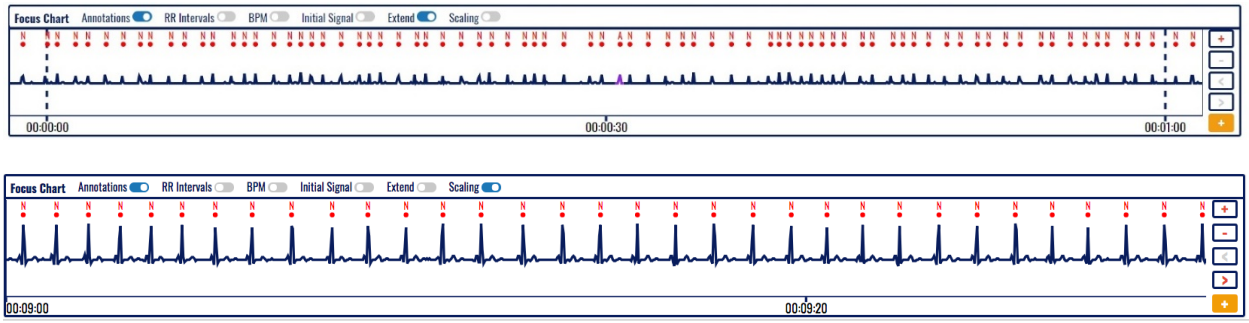

Figure 34: Focus chart.

The focus chart contains a header in the upper part, magnification control in the right part and time related information in the lower part. The main part visualizes the selected ECG segment.
The displayed ECG strip is a representation of a filtered signal using a band-pass filter in the range [0.5Hz, 30Hz] with a filter length of 0.2s. This eliminates the baseline drift and high frequency noise. The doctor can activate a display of the original recording in addition to this representation, to analyze details on the ECG signal.
All detected beat types are indicated in the ECG strip by a corresponding annotation color (Figure 35). The normal beat annotations are not marked or indicated on the ECG strip.
A semi-transparent colored rectangle on the focus chart maybe used to indicate a detected episode (Figure 35). Discretely, the title of rhythm the episode is written on the background of these rectangles behind the displayed ECG signal to avoid any misinterpretations.

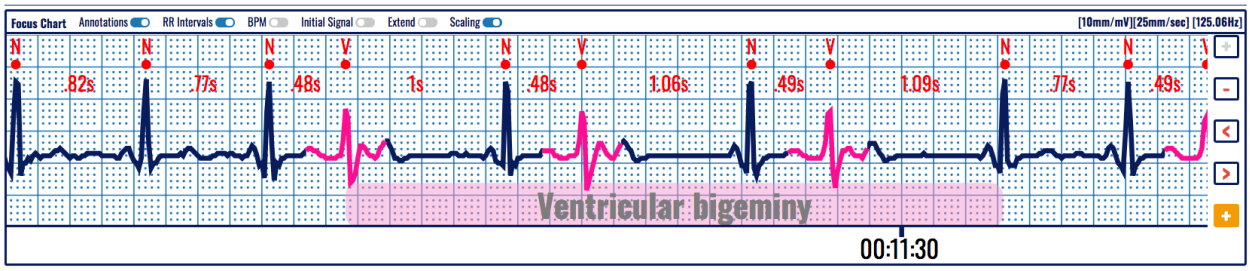

Figure 35: A focus chart with identified beats and rhythm episode.

Magnification levels

There are four different levels of magnification:

- X1 – the focus chart visualization window fits to the entire ECG strip (Figure 36);
- X2 – the focus chart visualization window fits to half the length of the ECG strip (Figure 37);
- X4 – the focus chart visualization window fits to fourth of the length of the entire ECG strip (Figure 38);
- X8 – the focus chart visualization window fits to eighth of the length of the entire ECG strip and the height of the focus chart is doubled for better visualization (Figure 39);

A double click on a particular location on the ECG strip or focus chart will result in doubling the magnification level of displayed ECG in the focus chart. You can use the (+) and (-) navigation buttons to increase or decrease the magnification level.

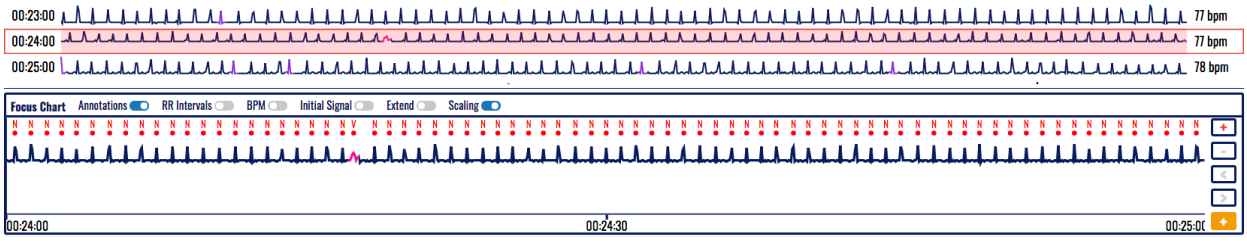

Figure 36: Selected ECG strip segment and focus chart presenting annotated beats.

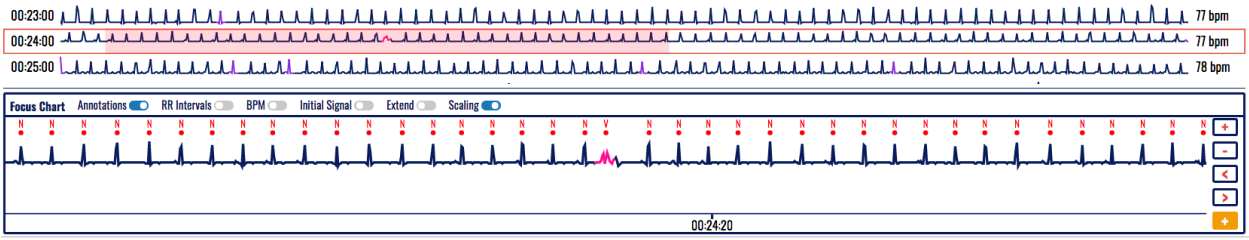

Figure 37: Selected ECG strip segment with 2x magnification and focus chart presenting annotated beats.

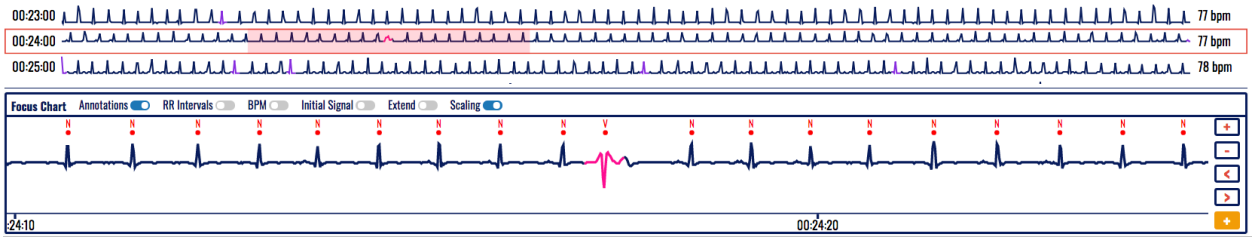

Figure 38: Selected ECG strip segment with 4x magnification and focus chart presenting annotated beats.

Figure 39: Selected ECG strip segment with 8x magnification and focus chart presenting annotated beats.

Time markings below the ECG strip are:

- In case of X1 magnification the time markings are drawn for each 15s in case of half minute ECG strip and for each 30s in case of a full minute ECG strip;
- In case of X2 magnification the time markings are drawn for each 10s in case of half minute ECG strip and for each 20s in case of a full minute ECG strip;
- In case of X4 or X8 magnification the time markings are drawn for each 5s in case of half minute ECG strip and for each 10s in case of a full minute ECG strip;

Focus chart header

The focus chart header section, located above the ECG strip, contains a list of toggle controls which affect the displayed information on the focus chart:

- Annotations toggle – toggles the display of annotation markings above the identified wave components; default value: on;
- RR intervals toggle – toggles the display of the duration of the RR intervals in seconds; default value: off;
- BPM toggle – toggles the display of BPM value for each RR interval; additionally, the values are interconnected and vary in height, so that they form a chart on their own; default value: off;
- Initial signal toggle – toggles the display of the original/initial/unfiltered signal in addition to the filtered signal; default value: off;
- Extend toggle – if on, adds 2s segments to each side of the ECG strip so that the findings on the ends of the ECG strip have greater transparency; default value: off;
- Scaling toggle – toggles whether the amplitude scaling will be done in a way that the signal amplitude range spans optimally with the height of the chart with the limitation that the amplitude can be maximally amplified to a magnitude of 4 (when scaling is turned off), or the amplitude will be in accordance with the standard ECG grid mash (when scaling is turned on); default value: off.

In the case a grid is displayed, the right part of the focus chart header represents information about the presented scale and sampling frequency.

Display of grid and beat annotations

Annotations can be displayed by a corresponding beat type identification over the red marked dot for detected heart beats (Figure 40, Figure 41, Figure 45 and Figure 46). When annotations are not displayed, then each detected heart beat is marked only by a red dot (Figure 42, Figure 43 and Figure 44).

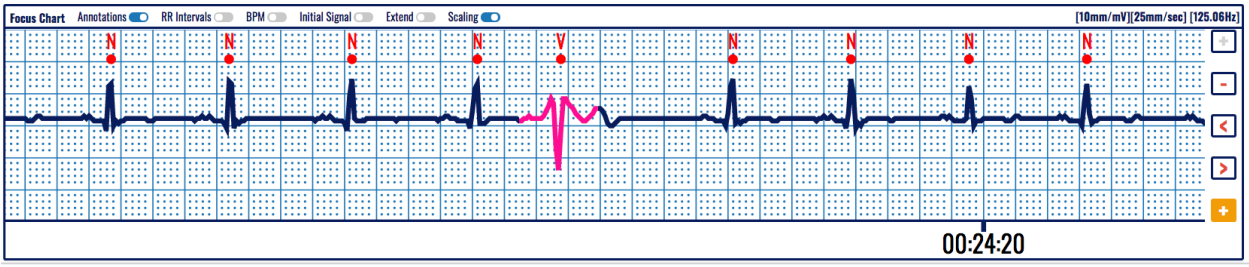

Figure 40: Focus chart presenting annotated beats of an ECG strip on a predefined grid.

Grid is usually used in ECG strips (Figure 40) for easier calculation of distances between characteristic features, such as beat to beat distance (RR interval), PR or ST segment width, etc. When there is no grid, then the displayed ECG (Figure 41) is scaled to the allowed height.

Figure 41: Focus chart of annotated ECG strip presented without grid.

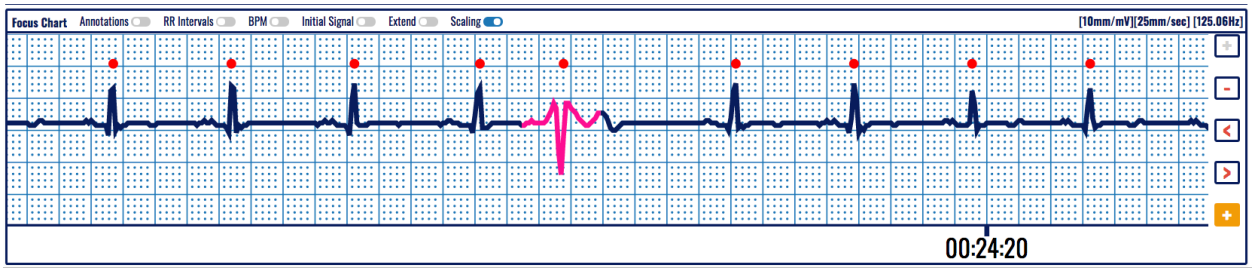

Figure 42: Focus chart presenting an ECG strip on a predefined grid.

Extended heart rate-related info

When corresponding toggle switch is activated, then the RR intervals are displayed in seconds (Figure 43) to represent distances between detected consecutive heart beats.

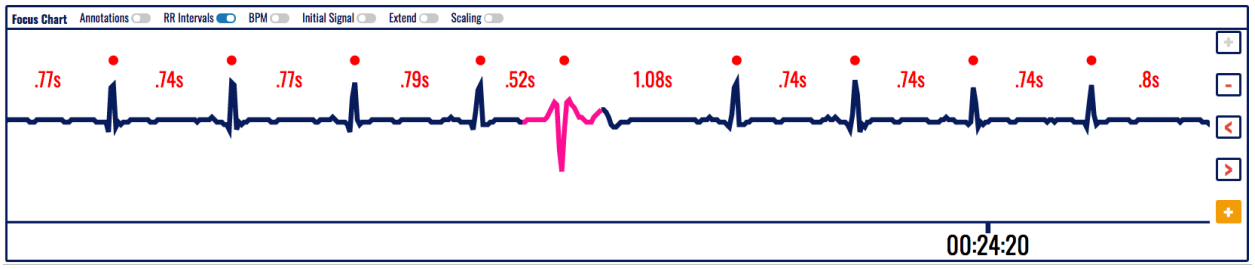

Figure 43: Focus chart without annotations including the RR intervals.

The toggle switch on BPM results with a display of a heart rate chart corresponding to each detected heart beat. This will show current changes of the heart rate (Figure 44).

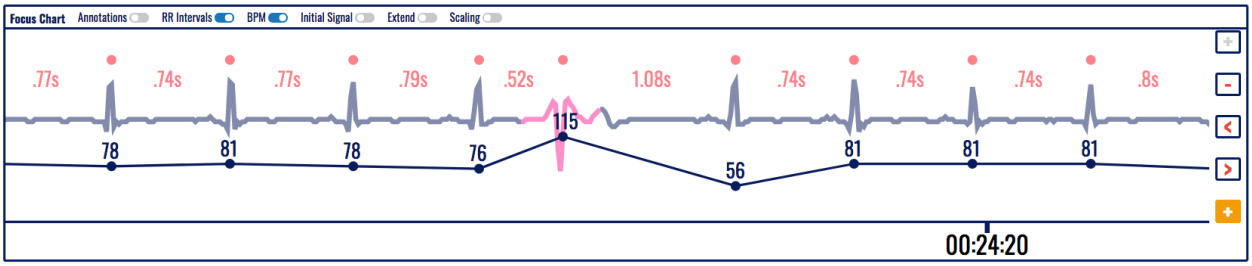

Figure 44: Heart rate information along with RR intervals on the focus chart.

Extended visualization features

The initial (original) ECG recording (Figure 45) is displayed when corresponding toglle switch is activated. It is displayed on top of the filtered signal and can be used for easier identification of the beat type or rhythm episode analysis.
Note that the original signal may have a baseline drift and not all elemnts to be visible.

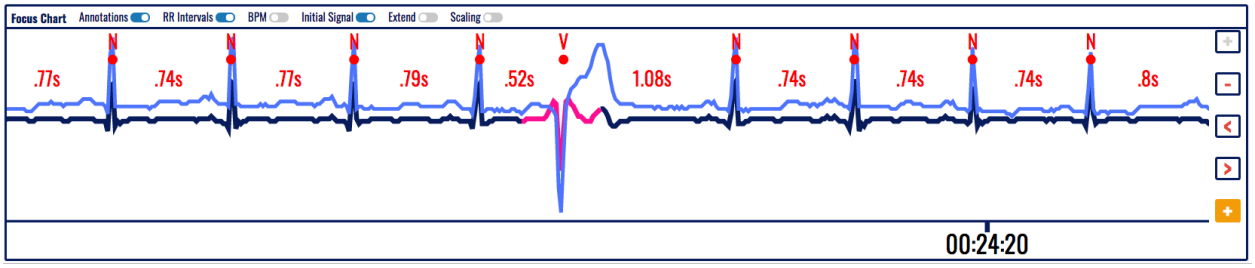

Figure 45: initial (original) ECG recording presented on top of the annotated filtered signal with RR intervals.

Sometimes, a beat may occur in the very begging or ending of the ECG strip, and therefore, it is very difficult to analyse it in a broader context. The extend feature (Figure 46) allows extension of the vsiible part, so even this beat can be analyzed in context of previous or next heart beats. It is activated or deactivated by the corresponding toggle switch.

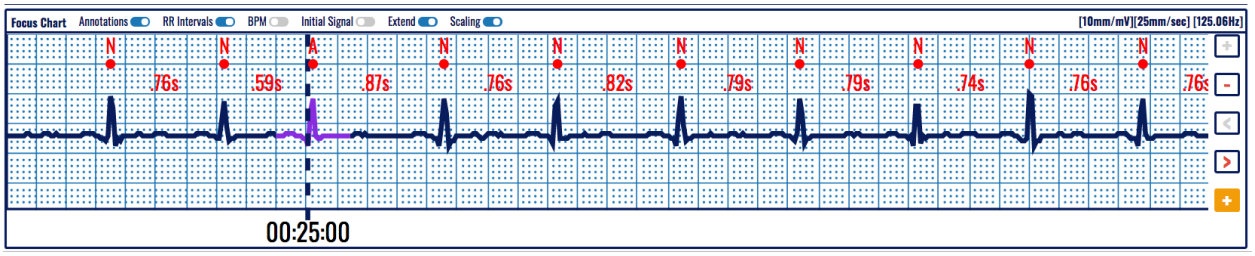

Figure 46: Extend segment function used on focus chart on a predefined grid.

Magnification and navigation

On the right side of the ECG strip in the focus chart, there are four control buttons that assist the focus chart navigation and magnification:

- Zoom in button (+) - increases the magnification level;
- Zoom out button (-) - decreases the magnification level;
- Slide left button (<) - slides the strip to the left for one Nth of its length, where N is the magnification coefficient;
- Slide right button (>) - slides the strip to the right for one Nth of its length, where N is the magnification coefficient;
- Add segment to report (+) on orange background – used for reporting purpose.

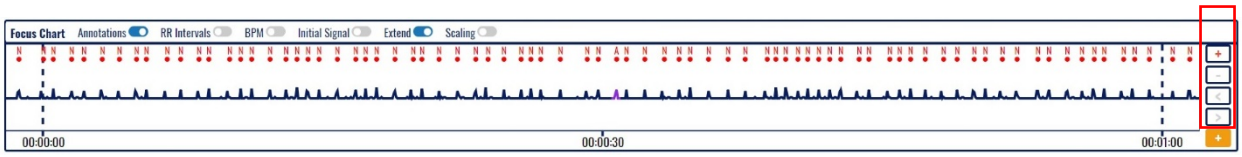

Figure 47: An extended display of the ECG in the focus chart (1 sec out of 30 sec borders).

The center point of the 7.5s ECG strip is the center point of the visible part of the ECG strip from the focus chart. The annotations which are not marked as normal are indicated on the ECG strip by coloring the area around the annotation with the corresponding annotation color. The detected episodes are marked on the ECG strip by drawing a semi-transparent colored rectangle, matching the area affected, and by discretely drawing the title of the episode within the semi-transparent colored rectangle.

With the change of magnification, the semi-transparent selector from the currently selected ECG strip in the list of ECG strips changes its length so that it corresponds to the magnification level of the focus chart. In the case the magnification level is X4 or X8 and the scaling is turned on, the ECG grid mash is drawn behind the ECG signal and "[10mm/mV][25mm/sec] [125.06Hz]" marking appears on the far right corner of the focus chart section header.
In a case of magnification level greater than X1, the focus chart can be dragged towards left or right, changing its horizontal offset. Changing the horizontal offset of the focus chart, the semi-transparent selector from the currently selected ECG strip in the list of ECG strip changes its horizontal offset so that it corresponds to the horizontal offset of the focus chart.
A double click on the focus chart will double its current magnification level, unless it is already on its maximum level of magnification.
Below the assistive navigation buttons there is another button marked with (+) in orange background so that it differs from the other assistive navigation buttons. It is used to add an ECG strip with a duration of 7.5s for the report generation.

4.7. Dashboard

The dashboard navigator is toggled on a click of the toggle switch between heart rate and dashboard in the monitoring header section.

The role of the dashboard (Figure 48) is to provide quick access to information on detected beat types and rhythm episodes for a particular period, and to navigate through appearances of detected arrhythmia beats and episodes. An additional visualization and monitoring tools is provided for detailed analysis of the detected arrhythmia.

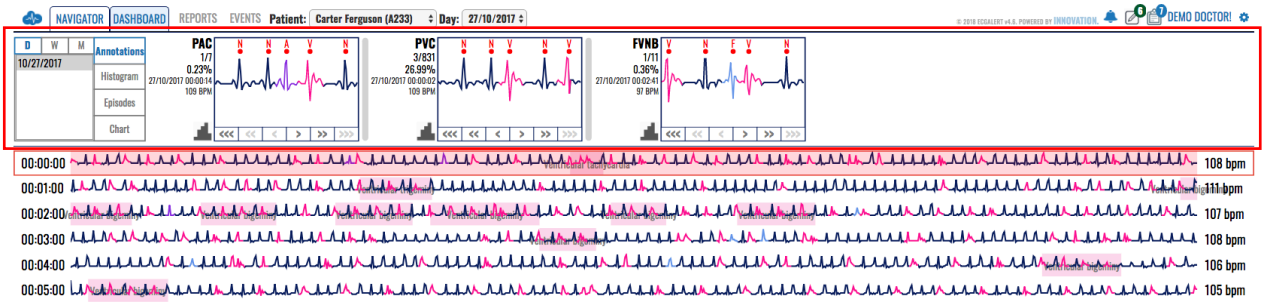

Figure 48: Dashboard displayed instead of hour selector over the list of ECG strips.

The dashboard information appears in the same area of the hour selector and ECG strip selector sections combined.

It is divided into two sections:

- Control section – located on the left of the dashboard; contains the controls which determine the content of the content section;
- Content section – located on the right of the dashboard; contains statistics and quick access to the annotations and episodes for a selected time period and information domain;

The control section (Figure 49) is divided into two subsections:

- Period selector section (D, W, M) – located on the left side of the control section used to select the period for the content section; and
- Information selector section – located on the right side of the control section and used to select the information domain for the content section.

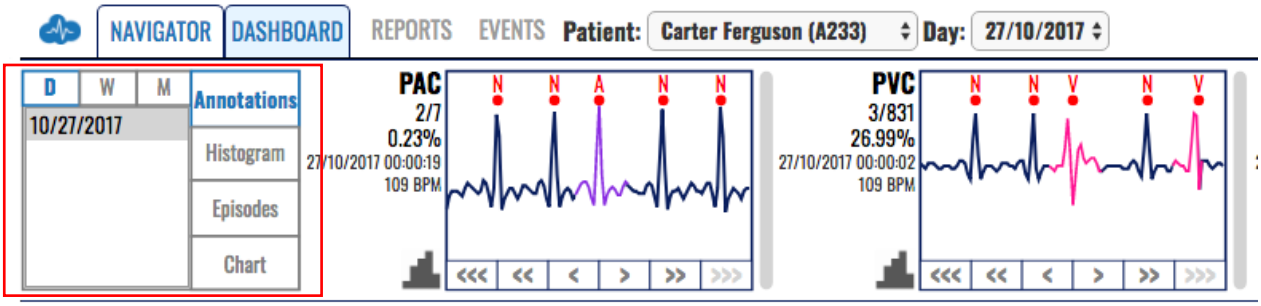

Figure 49: Control section of dashboard.

The period selector section (left side of control section Figure 49) has a header on the top and a list of date ranges. If there are more dates than those displayed in the list, then there is a vertical navigation through the list.

The header is made up of a toggle switch with three options:

- Day toggle (D);
- Week toggle (W);
- Month toggle (M);

Only one toggle option can be active at a given time. The presented summary information in the content section corresponds to the period selected by this toggle switch.
The list of dates contains available periods with duration in accordance with the active toggle option from the header. Only one list selection can be active at a given time.
The right part of the control section is called information domain selector (Figure 50).

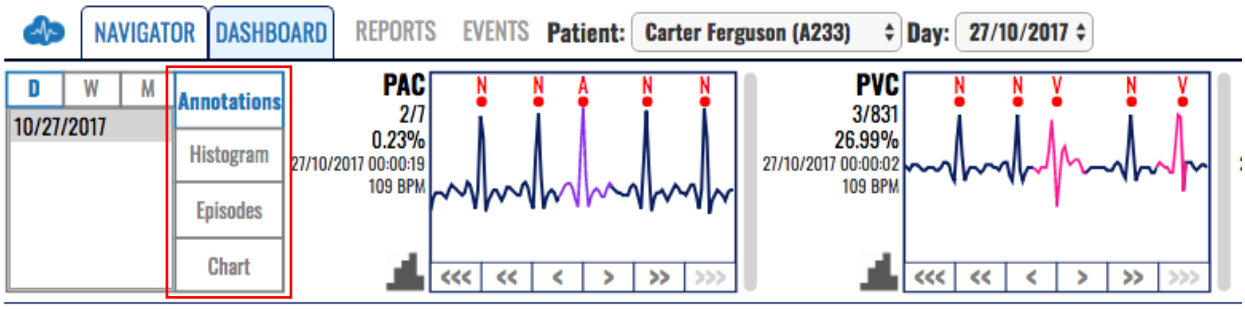

Figure 50: Information domain selector in the control section of dashboard.

You can select one of four available information domains, by clicking a corresponding toggle control. Only one information domain can be active at a given time. The information domains include:

- Annotations – provides a list of annotations detected in the selected period;
- Histogram (of annotations) – provides an annotation histogram for detected annotations in the selected period;
- Episodes – provides a list of rhythm episodes detected in the selected period;
- Chart (Histogram of rhythm episodes) – provides a histogram of detected rhythm episodes in the selected period;

The content section of the dashboard located on the right side of the dashboard navigator (Figure 51) provides statistical info and quick access to the selected information domain (beat annotations or rhythm episodes) for a time period selected from the dashboard control panel.

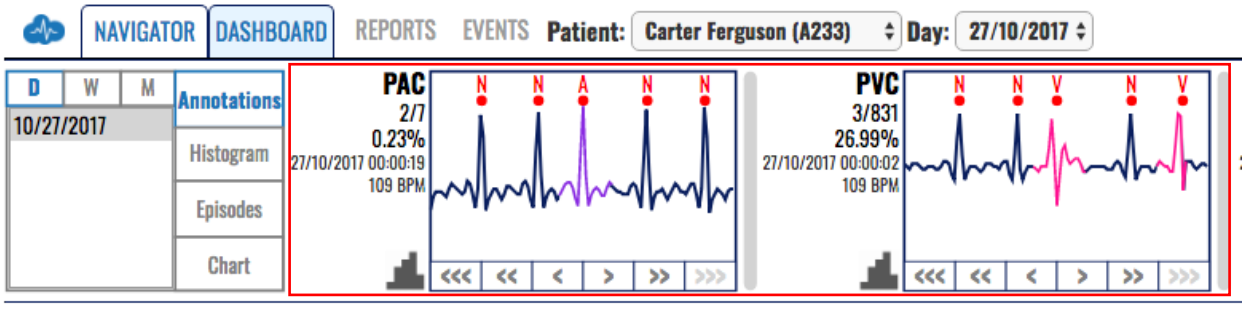

Figure 51: Content section of dashboard.

Dashboard of annotated beats

The dashboard can display several forms, including the annotated beats (Figure 51). When the information domain is set to annotations, the content section provides information box (Figure 52) for each annotation detected in the selected period.

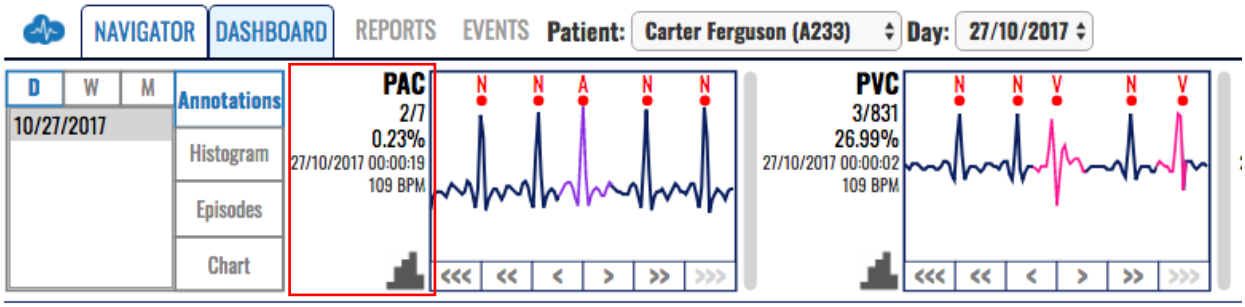

Figure 52: Information box is associated to each annotated beat type.

The information box contains:

- an abbreviated name of the annotation beat type,
- current identification and total number of beat type occurrences (the first number is the current beat identification and the second the total number of occurrences)
- percentage of beat type occurrences relative to the total number of detected heart beats (QRS waves) in the selected period,
- the date and timestamp of the currently displayed beat type,
- heart rate value derived from the displayed annotations expressed in BPM, and
- column chart icon which is shortcut to the corresponding annotation histogram column chart (shortcut for switching to annotation histogram context of the content section).

Right from the information box there is:

- a display box with an ECG strip presenting the annotated beat type, and
- navigation buttons bellow the picture containing links:
    - <<< the first annotated beat type in the previous day (if there is such a record),
    - << the first annotated beat type in the analyzed period,
    - < the previous annotated beat type in the analyzed period,
    - > the next annotated beat type in the analyzed period,
    - << the last annotated beat type in the analyzed period, and
    - >>> the first annotated beat type in the next day (if there is such a record).

The display box presents a thumbnail preview with the current annotation beat type located in the middle of the box, so you can analyze it in context to the previous and next beats. The beat is colored corresponding the beat type for easier identification.

A click in the display box results with opening an extended viewer (explained details in the next sections) in order to enable a better visualization of the detected arrhythmia beat.

The annotation abbreviation and the annotation display box have as tooltip information on mouse over the full name of the annotation. A navigation button can be inactive if there are no annotated beat types for the navigation criteria.

In a case the content section width is not sufficient to fit all annotation information boxes, the content section is extended by the means of vertical slide mechanism.

Annotation histogram of detected beat types

Dashboard can present a histogram of annotated beats (Figure 53). The histogram shows the count of occurrences calculated per hour, so you can easily monitor when these detected beats occurred.

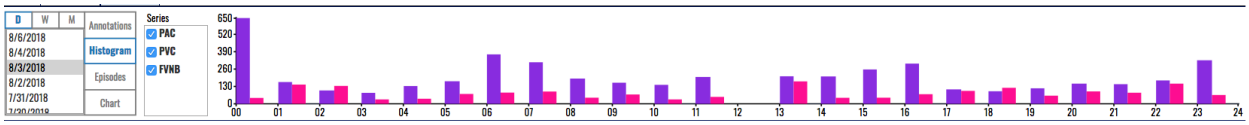

Figure 53: Column bar histogram of annotated beat types in the dashboard.

A beat type selector (called series Figure 54) appears right of the information domain selector. It contains a list of detected beat types and check boxes next to them to select what will be displayed in the content box. A multiple beat type information can be showed within single column chart if more than one beat type is selected. By default, all beat types are selected.

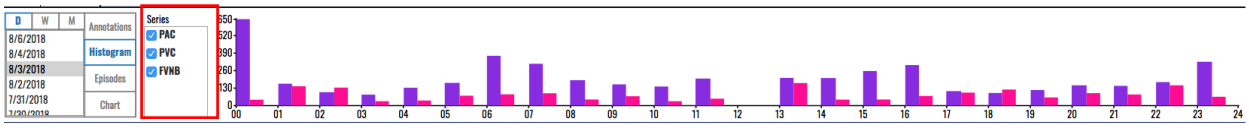

Figure 54: Beat type selector box for histogram of annotated beats in dashboard.

The histogram is a column view chart and each detected beat type is presented with different color. The scale is displayed on the left side next to the vertical axis and the presented values are in numbers (occurrences of detected beat type). The horizontal axis features time intervals, whilst the vertical, the number of occurrences of corresponding beat type in an hour.
The monitoring settings page (invoked by clicking the settings icon in the application header) can be used to setup other views of the histogram, such as line chart (Figure 55) instead of column bar chart (Figure 53). You can choose presentation of the histogram with relative percentages (Figure 56) instead of absolute values (Figure 53). Details on controls which toggle the histogram formatting can be found in the monitoring settings section.

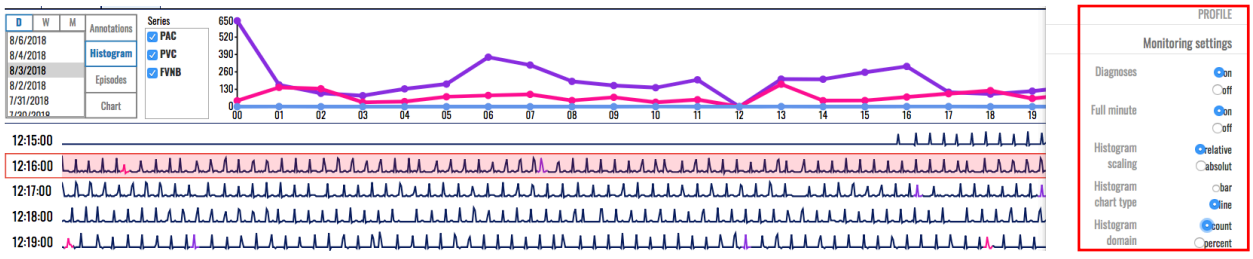

Figure 55: Histogram of detected beat types presented by lines instead of column bars.

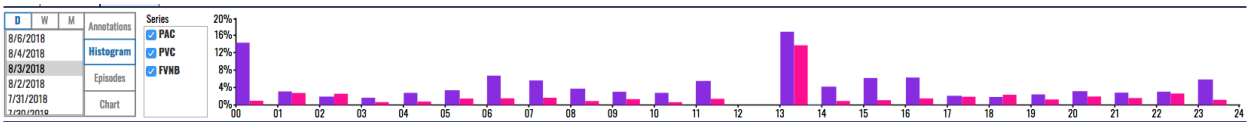

Figure 56: Column bar histogram of annotated beat types with relative values.

Dashboard of rhythm episodes

Dashboard can present detected rhythm episodes (Figure 57) by clicking on the corresponding toggle switch button.

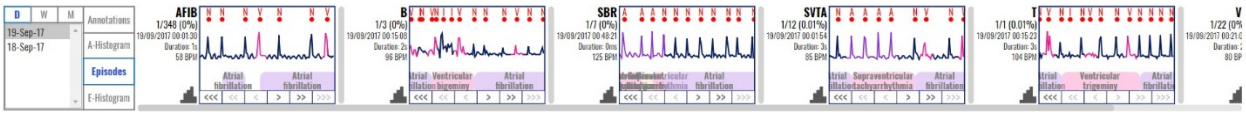

Figure 57: Dashboard of detected rhythm episodes.

When the information domain is set to episodes, the content section provides information box for each episode detected in the selected period.

The information box for detected rhythm episodes contains:

- an abbreviated name of the episode,
- current identification and total number of rhythm episodes (the first number is the current episode identification and the second the total number of episodes),
- duration of current episode and total duration of all episodes, along with percentage (relative to the total recording duration in the selected period),
- the date and timestamp of the beginning of the currently displayed rhythm episode,
- the average, minimum and maximum heart rate of the analyzed episode, and
- column chart icon which is shortcut to the corresponding episode histogram column chart (shortcut for switching to episode histogram context of the content section).

Right from the information box there is:

- a display box with an ECG strip presenting the analyzed episode, and
- navigation buttons bellow the picture containing links:
  - <<< the first rhythm episode in the previous day (if there is such a record),
  - << the first rhythm episode in the analyzed period,
  - < the previous rhythm episode in the analyzed period,
  - > the next rhythm episode in the analyzed period,
  - << the last rhythm episode in the analyzed period, and
  - >>> the first rhythm episode in the next day (if there is such a record).

The episode display box gives a thumbnail preview of the current episode. A tooltip appears on mouse over for the episode abbreviation and the information box have.

A navigation button can be inactive in a case such an episode does not exist.

In the case the content section width is not sufficient to fit all episode information boxes, the content section is extended by the means of vertical slide mechanism.

Histogram of rhythm episodes

Dashboard can display a histogram of detected rhythm episodes (Figure 58) by clicking on episodes histogram button.

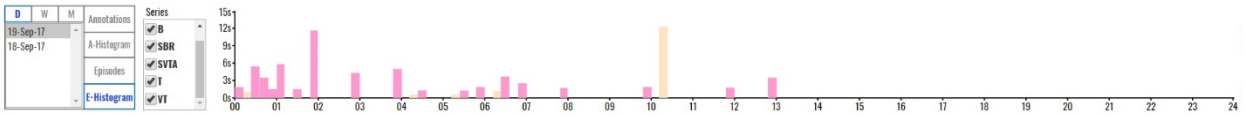

Figure 58: Histogram of detected rhythm episodes.

A column view of the episode histogram is displayed by default. You can select another type of presentation by the settings option, such as

The x-axis features time intervals, whilst the y-axis features the number of episode per time interval.
There is control which acts as series selector, so that multiple annotation information can be showed within single column chart. The series values can represent the number of episodes found in the period or their percentage relative to the sum of all R waves. The chart type can be either bar chart or line chart. The series numbers can be either in count or percent. The information domain can either relate to the episode number or episode duration. The controls which toggle the histogram formatting can be found in the monitoring settings section in the settings pane.

4.8. Extended Viewer

An extended viewer (Figure 59) can be displayed by clicking on a displayed window of annotated beats or detected rhythm episodes. The annotated beat is usually located in the middle of the presented ECG strip (Figure 59) or it displays a rhythm episode by locating the start at the left end of the displayed ECG strip (Figure 60).

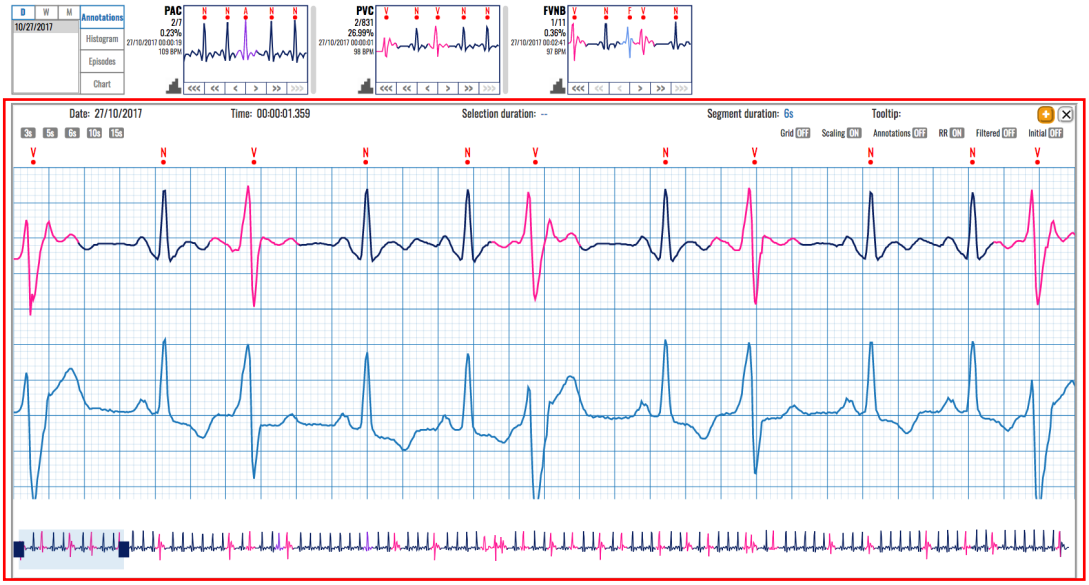

Figure 59: Extended viewer with an annotated beat in the middle.

Figure 60: Extended viewer of a rhythm episode located at the beginning if the ECG strip.

The visualization box for a detected annotated beat or rhythm episode acts as link to the extended viewer, which covers the area of list of ECG strips and the focus window.

The extended viewer contains a header row, control buttons, ECG strips presented on a grid and navigation slider. Its duration matches the one in the focus chart section.

Header row of extended viewer

The corresponding header has a timestamp of the ECG strip where the annotated beat is found or rhythm episode starts. It shows the segment duration information, selection duration, tooltip information and two buttons (add to report and close window). The tooltip presents the recorded values that correspond to the original signal when the mouse is pointing over this signal. The segment duration is indicated in seconds and this can be adjusted by a control button or adjusting the selection bounds in the navigation slider.

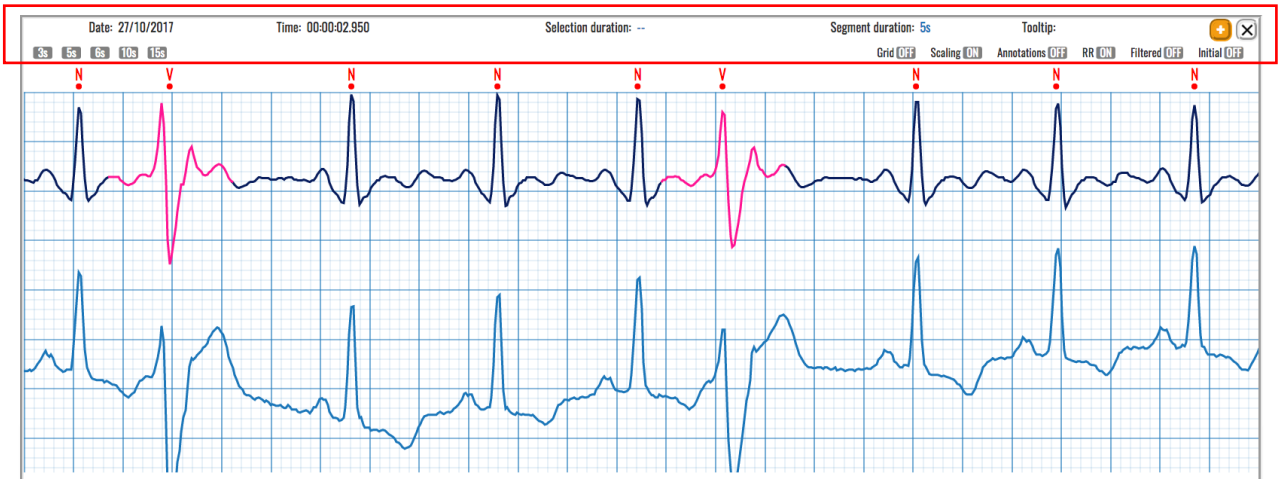

Figure 61: Header row of the extended viewer.

There are two buttons at the right end of this header. The first one adds the ECG strip to the report, and the second closes this window and returns back the control to the list of ECG strips.
The "add to report" button (Figure 62) will add an ECG strip with a duration of 7.5s to the pool of user predefined ECG strips for the report generation. If an annotated beat is selected, then the center point of the 7.5s ECG strip is the center point of the visible part of the ECG strip from the signal visualization pop-up window. If a rhythm episode is selected, then its start is the start of the ECG strip.

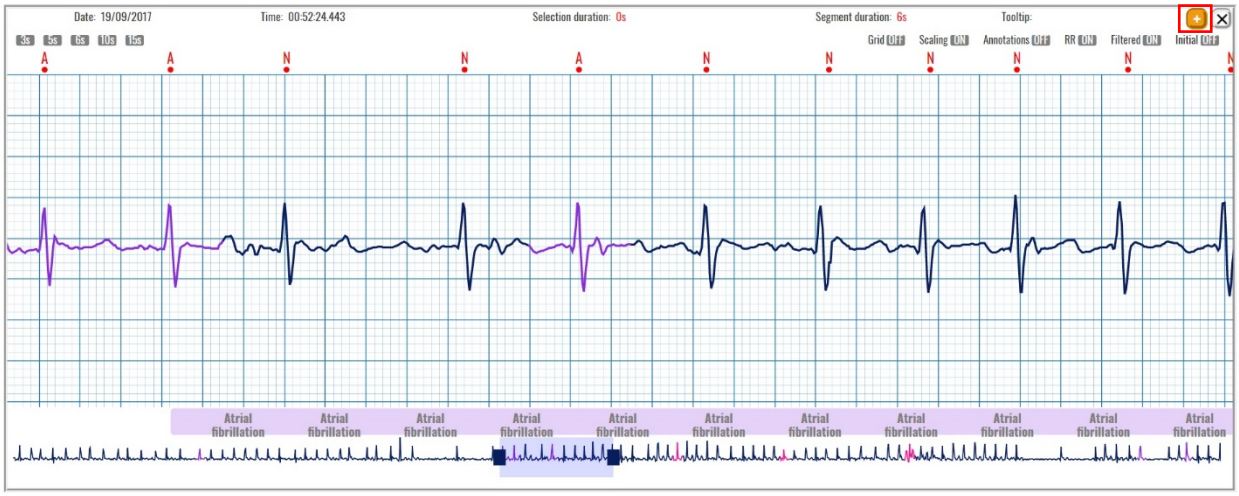

Figure 62: "Add to report" button on the extended viewer.

Control buttons

The row with control buttons is located below the header.
The left part contains control buttons for ECG strip duration. You can select among 3 sec, 5 sec, 6 sec, 10 sec (Figure 63), and 15 sec duration.

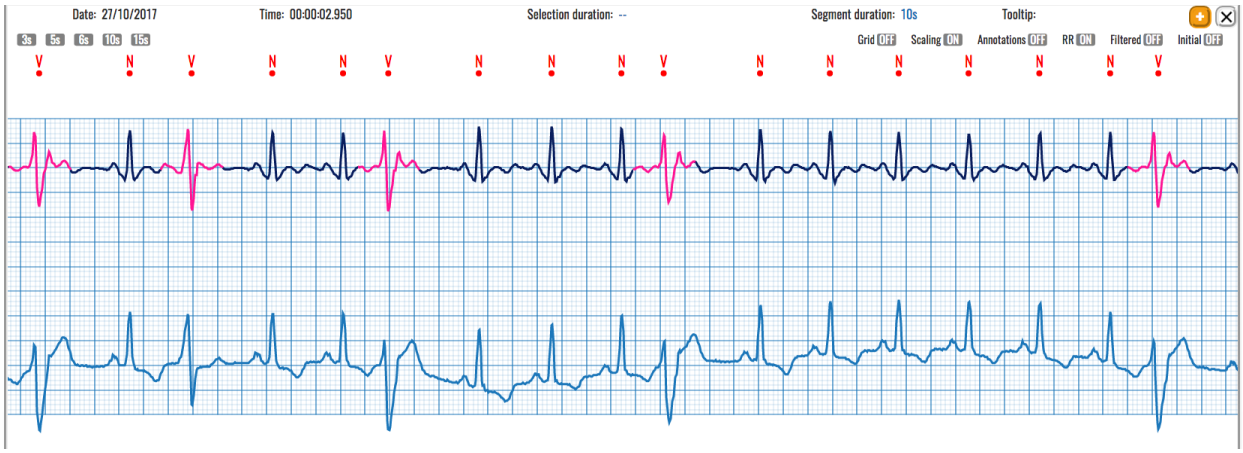

Figure 63: Extended viewer set to 10 sec duration displaying the original with baseline drift and filtered signal.

The corresponding segment duration indicates the value in the header row. The width (duration) of the displayed window can be also adjusted by the selection bounds in the navigation slider, as explained with navigation tools.
The right part of control buttons contains the following buttons: Grid, Scaling, Annotation, RR, Filtered. Next to each control button there is an OFF/ON switch which controls its appearance.
Default value of the grid is ON, enabling the background grid, so you can easily calculate the distances between RR, PR, QT or similar values. The grid uses a standard based on 25mm/sec and 10mm/1mV, used as a standard in processing of ECGs.
Scaling will scale the signal within the predefined vertical space.
Annotations appear for each detected beat type. They can be removed by the control button, so only the red dot will display the presence of a heart beat without identification of its type.
RR corresponds to RR interval between two consecutive beats and is expressed in seconds. Filtered will remove or add display of filtered signal, which is used for easier interpretation and detection of heart beats, eliminating the baseline drift (Figure 63) or high frequency noise. It slightly distorts the signal, but keeps its features.

Monitoring and navigation tools

The main part of the extended viewer displays two signals, the upper is the filtered signal and the lower the original recorded ECG strip.
The monitoring tools contain two features: mouse over feature and selection.
A mouse over feature sets an accent on the signal by making the analyzed point visible. Its values expressed as time offset relative to the indicated beginning and electrical value in mV are displayed as tooltip information (Figure 64).

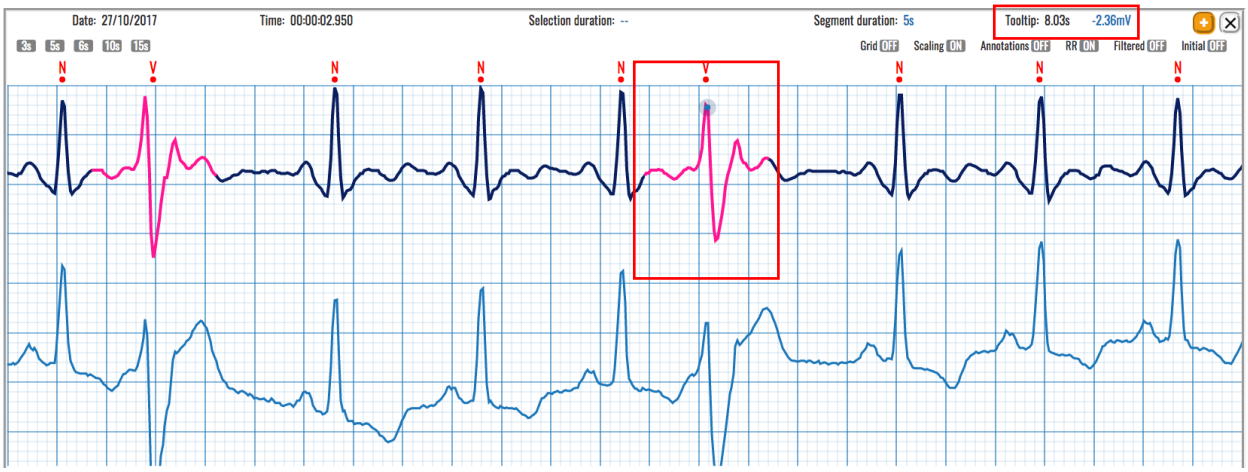

Figure 64: Mouse over displays a tooltip information of the analyzed point.

Drag and drop mouse action can be used make a selection, such as to indicate the width of a QRS for the analyzed V beat (Figure 65). The selection is shaded in darker background, and the width is displayed in the selection duration box.

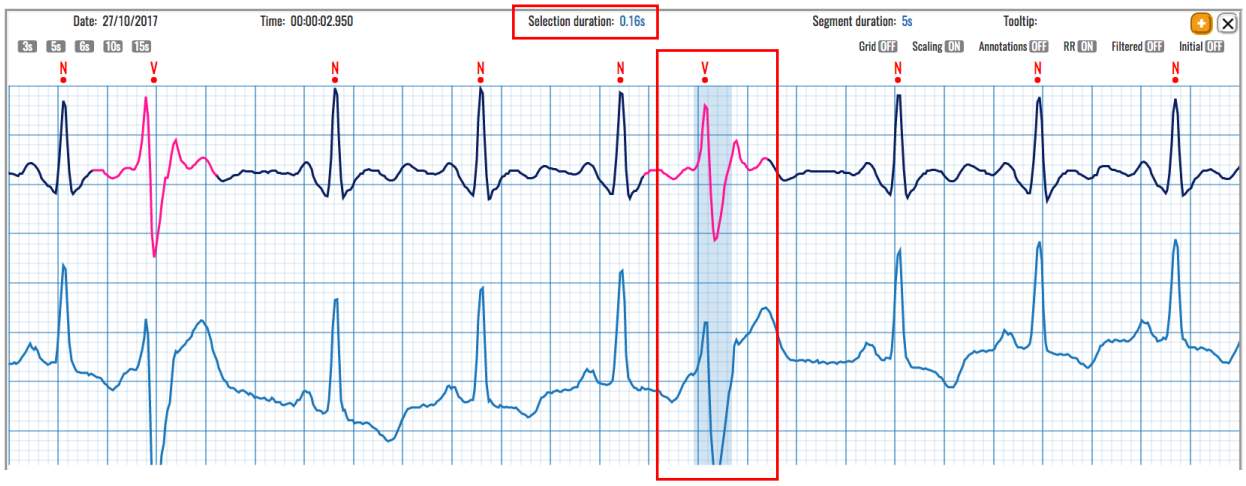

Figure 65: Mouse drag and drop make a selection of a QRS width of the V beat (duration info in the header).

Navigation tools

The navigation tools are available via the navigation slider. A displayed segment window (Figure 66) shows which part of the ECG strip is enlarged and presented in the main window by two signals (the filtered and original one).

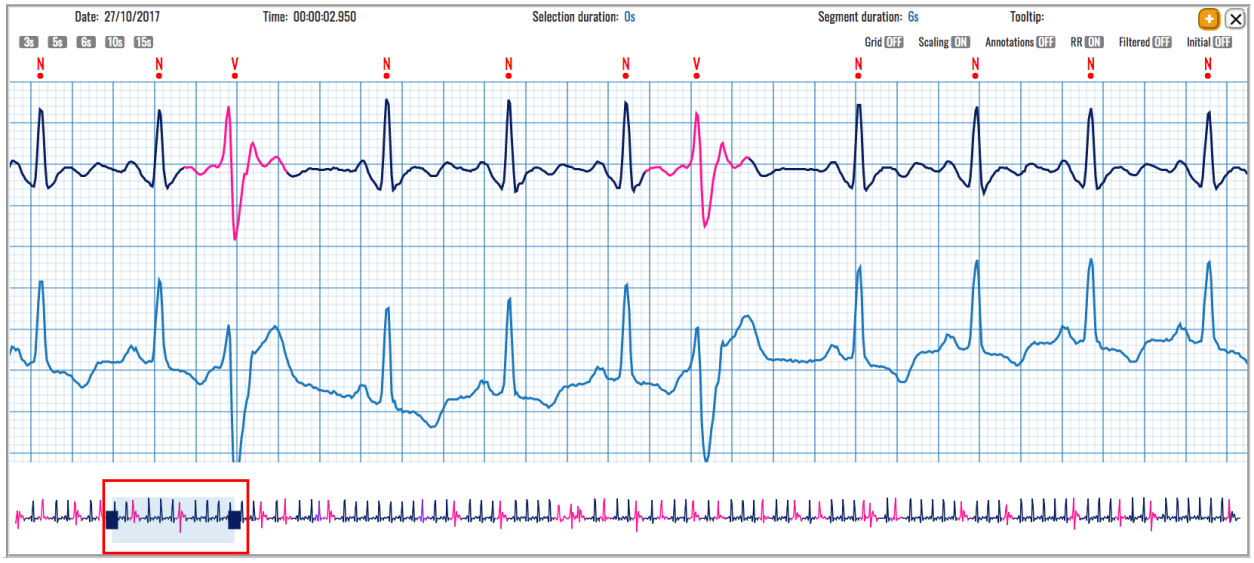

Figure 66: Displayed segment window on the navigation slider.

The left and right bounds of this segment window on the navigation slider can be moved left or right by a mouse drag and drop action. This will move the corresponding bound and make the segment wider or smaller.

The mouse drag and drop action can be also applied on the middle of the segment window of the navigation slider and this will result by sliding the displayed window over the ECG strip.

5. How to create a report

A report is created by clicking the report icon in the monitoring page header. The number next to the reporting tool indicates how many segments have been added in the report.
Each report (Figure 67) contains a header, summary info, detected beat types and rhythm episodes, significant histograms, selected segments, and opinion part.

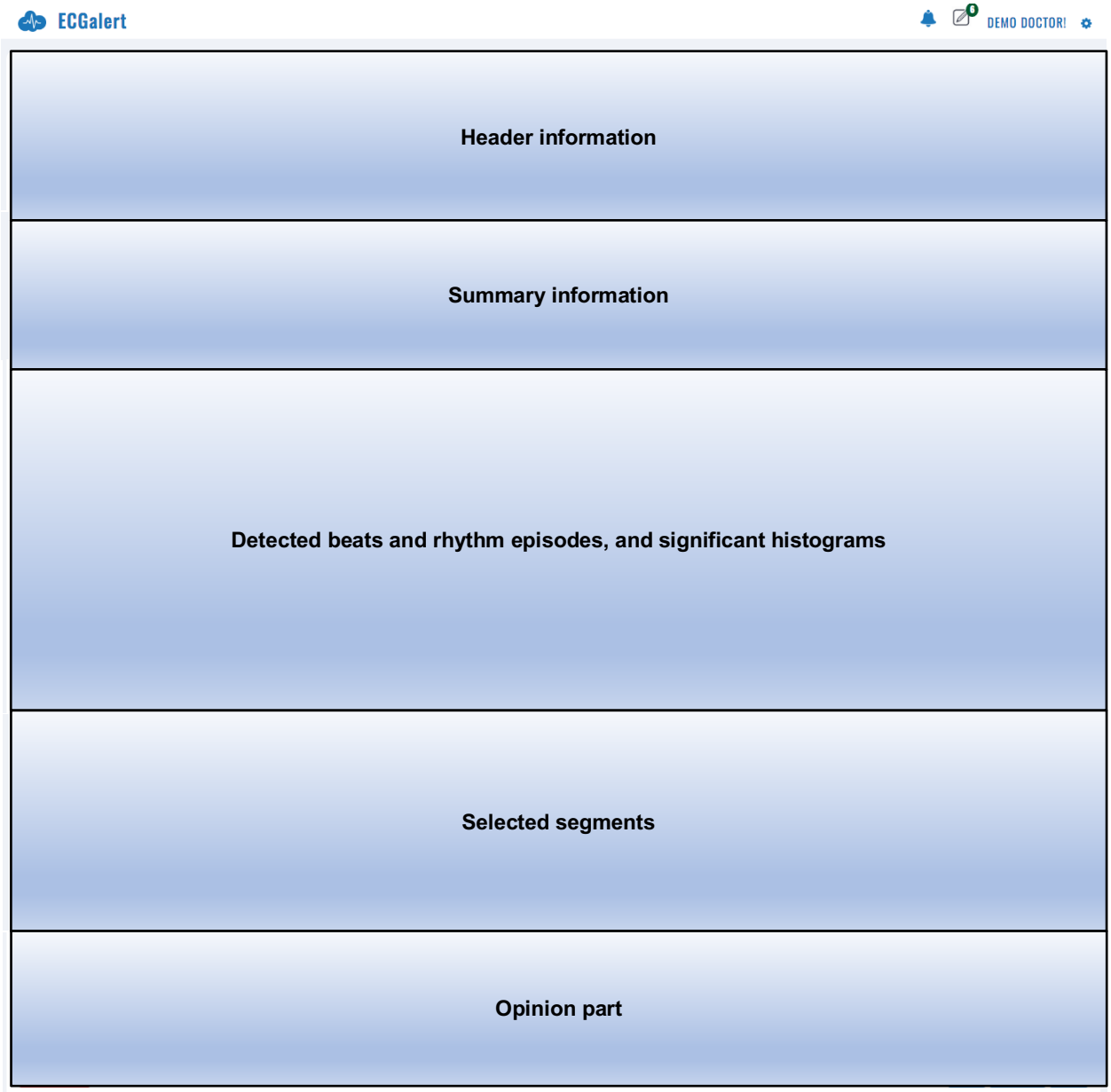

Figure 67: Report contents.

5.1. Header information

Header information (Figure 68) on the reporting page contains the application header, and three information parts.

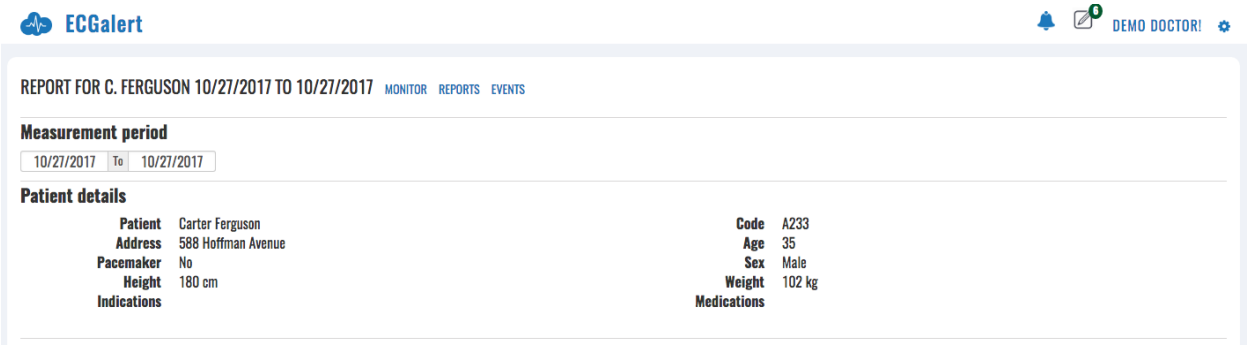

Figure 68: Report header.

Application header

The standard application header is located above the custom report header. It contains the ECGalert logo and link on the left side. The right side contains the system notification icon, completed reports icon, user's name and settings icon.
A click on system notification icon will display messages (if any) created by the operating system. The next icon will display a list of reports that the doctor has created and completed. The settings icon will open a drop-down menu to configure the monitoring settings, while the name in the application header and profile option from the settings drop-down menu will open a form to change the personal settings.

Report header row

The report header row contains the patient full name on the left side, followed by the current report period. This is followed by a quick access section with links to the monitoring, completed reports and event pages for the patient.

Measurement Period

After the report creation page is accessed, the doctor can adjust the measurement period and set a preferred information.
The monitoring period section consists of two date-picker controls (Figure 69) which determine the start and the end of the period for which the report is generated. The default values of the date-picker controls are set to the last recording date and a week before the last recording date, meaning that the default period duration for the report is one week.
The difference between the oldest and newest date is shown on the right of the date picker controls. The date picker controls can only select days when measurements were taken. The date-picker controls limit the availability of selectable dates in accordance with the dates for which measurements are present. After a selection from the date-picker controls is made, i.e. the measurement period is changed, the page is reloaded and it features information on the newly selected measurement period.

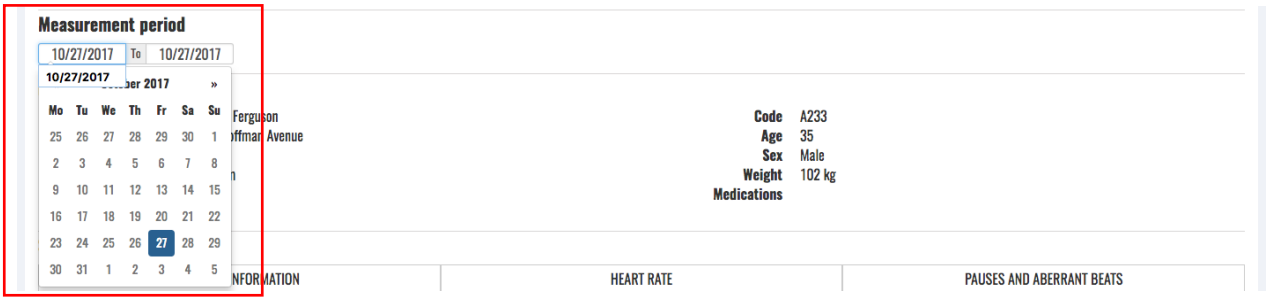

Figure 69: Date selector for the report measurement period.

Patient Information

The patient details (Figure 70) are listed in the patient information section, including:

- Patient – the patient's full name;
- Code – the code of the patient;
- Address - the patient's address;
- Age – the age of the patient;
- Pacemaker – indicates whether the patient is using a pacemaker device;
- Weight – the weight of the patient;
- Height – the height of the patient;
- Indications – Deviations the patient is prone to, genetic predispositions for certain diseases, medical history and other relevant data to the ECG findings; and
- Medications - the medications the patient was taking during the measurement period.

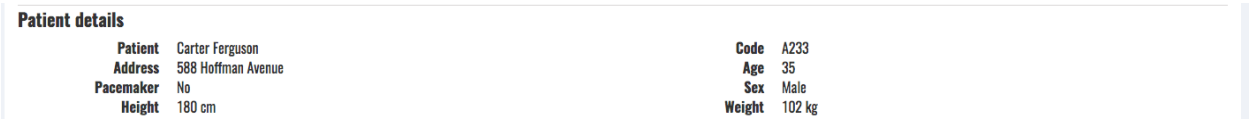

Figure 70: Patient details displayed in the report.

5.2. Summary Information

The summary section (Figure 71) is divided into six mandatory subsections:

- General information;
- Heart rate;
- Heart rate variability;
- Pulses and aberrant beats;
- Ventricular ectopy; and
- Supraventricular ectopy

In addition, depending on detected arrhythmia of the patient it contains subsections for

- Rhythm episodes related information;

Summary Information

GENERAL INFORMATION		HEART RATE		PAUSES AND ABERRANT BEATS	
Analyzed Beats	129476	Minimum HR-4	25 bpm at 19-Sep-17 04:56:24	SA Total	0
Total Recording Duration	1.05:51:30	Maximum HR-4	200 bpm at 18-Sep-17 23:39:29	Maximum SA	/
ECG Monitoring Period Start	18-Sep-17 07:01:30	Average HR-24 Hours	72 bpm	Micro SA Total	0
ECG Monitoring Period End	19-Sep-17 12:53:00	Minimum HR-Hourly	53 bpm at 18-Sep-17 20:00:00	Total Aberrant Beats/Runs	0
		Maximum HR-Hourly	104 bpm at 19-Sep-17 02:00:00		
HEART RATE VARIABILITY		**VENTRICULAR ECTOPIES**		**SUPERAVENTRICULAR ECTOPIES**	
SDNN	275 ms	VE Total	2612	SVE Total	1917
ASDNN	177 ms	VE-Pair Total	203	SVE Pair Total	88
SDANN	104 ms	Short V-Runs (3≤n<6)	46	Short SV-Runs (3≤n<6)	10
NN50	128375 / 129476	Long V-Run Total (n≥6)	0	Long SV-Run Total (n≥6)	1
pNN50	100%	Longest V-Run	5 at 18-Sep-17 08:25:13	Longest SV-Run	6 at 19-Sep-17 10:42:01
rMSSD	268 ms	Maximum HR Long V-Run	/	Maximum HR Long SV-Run	57 bpm at 19-Sep-17 10:42:01
Min Spectral Power Hour	0	Minimum HR Long V-Run	/	Minimum HR Long SV-Run	57 bpm at 19-Sep-17 10:42:01
Max Spectral Power Hour	0	VE's per 1000	20	SVE's per 1000	15
		VE's per Hour	87	SVE's per Hour	64
ATRIAL FIBRILLATION		**VENTRICULAR BIGEMINY**		**SINUS BRADYCARDIA**	
Number of episodes	418	Number of episodes	6	Number of episodes	8
Total duration	08:43:46 (29.24%)	Total duration	16s (0.01%)	Total duration	15s (0.01%)
Longest duration	00:20:10 at 19-Sep-17 00:21:01	Longest duration	3s at 18-Sep-17 13:42:08	Longest duration	12s at 19-Sep-17 10:41:55
Maximum HR	139 bpm at 19-Sep-17 02:30:01	Maximum HR	119 bpm at 19-Sep-17 01:34:34	Maximum HR	160 bpm at 18-Sep-17 23:16:02
Minimum HR	24 bpm at 19-Sep-17 04:20:24	Minimum HR	69 bpm at 18-Sep-17 13:42:08	Minimum HR	59 bpm at 19-Sep-17 10:41:55
SUPRAVENTRICULAR TACHYARRHYTHMIA		**VENTRICULAR TRIGEMINY**		**VENTRICULAR TACHYCARDIA**	
Number of episodes	13	Number of episodes	2	Number of episodes	45
Total duration	14s (0.01%)	Total duration	8s (0.01%)	Total duration	00:01:24 (0.08%)
Longest duration	2s at 19-Sep-17 00:01:54	Longest duration	5s at 18-Sep-17 09:29:06	Longest duration	3s at 18-Sep-17 19:16:18
Maximum HR	125 bpm at 19-Sep-17 06:39:51	Maximum HR	104 bpm at 19-Sep-17 00:15:23	Maximum HR	176 bpm at 19-Sep-17 06:59:19
Minimum HR	78 bpm at 19-Sep-17 04:27:44	Minimum HR	71 bpm at 18-Sep-17 09:29:06	Minimum HR	45 bpm at 18-Sep-17 19:16:18

Figure 71: Report summary info.

General info

The general information section contains information on:

- Analyzed beats – number of all QRS waves in the analyzed period;
- Total recording duration – the time difference before the first and last recording the report period;
- Normal sinus rhythm duration – reflecting the corresponding time;
- ECG monitoring period start – the start of the report period;
- ECG monitoring period end – the end of the report period;

The heart rate section contains information on:

- Minimum HR-4 Intervals – the minimum average BPM value of all consecutive 4 minutes;
- Maximum HR-4 Intervals - the maximum average BPM value of all consecutive 4 minutes;
- Average HR-24 Hours – the average BPM value for the whole report period;
- Minimum HR-Hourly - the minimum average BPM value of all consecutive hours;
- Maximum HR-Hourly – the maximum average BPM value of all consecutive hours;

The pauses and aberrant beats information section contains information on:

- SA Total – the total number of sinoatrial arrests;
- Maximum SA – the duration longest sinoatrial arrest;
- Micro SA Total – the total number of micro sinoatrial arrests;
- Total Aberrant Beats/Runs – the total number of aberrant beats or runs;

Heart rate variability

The heart rate variability section contains information on:

- SDNN – standard deviation of all RR intervals; expressed in ms;
- ASDNN - mean value of the standard deviations of all t-minute intervals in ms;
- SDANN - standard deviation of the means of the RR intervals for all 5-minute subintervals in ms;
- NN50 - the number of RR interval differences of successive RR intervals greater than 50 ms;
- PNN50 - NN50 as a percentage of all allowed RR intervals;
- RMSSD - root mean square of successive RR differences in ms;
- Min Spectral Power Hour;
- Max Spectral Power Hour;

Ventricular and supraventricular sections

The ventricular ectopies' section contains information on:

- VE Total – total number of ventricular ectopies;
- VE-Pair Total – total number of couplets of ventricular ectopies;
- V-Run Total – number of successive ventricular ectopies series where the number of successive beats exceeds 5;
- Longest V-Run – the longest number of successive ventricular ectopy beets exceeding 5;
- Maximum HR V-Run – the maximum BPM value of all ventricular ectopy runs exceeding 5 successive beats;
- Minimum HR V-Run - the minimum BPM value of all ventricular ectopy runs exceeding 5 successive beats;
- VE's per 1000 – average number of ventricular ectopies per 1000 beats;
- VE's per Hour – average number of ventricular ectopies per hour;

The supraventricular ectopies section contains information on:

- SVE Total – total number of supraventricular ectopies;
- SVE-Pair Total – total number of couplets of supraventricular ectopies;
- SV-Run Total – number of successive ventricular ectopies series where the number of successive beats exceeds 5;
- Longest SV-Run – the longest number of successive supraventricular ectopy beets exceeding 5;
- Maximum HR SV-Run – the maximum BPM value of all supraventricular ectopy runs exceeding 5 successive beats;
- Minimum HR SV-Run - the minimum BPM value of all supraventricular ectopy runs exceeding 5 successive beats;
- SVE's per 1000 – average number of supraventricular ectopies per 1000 beats;
- SVE's per Hour – average number of supraventricular ectopies per hour;

Detected episodes

The summary information section, in addition to the mandatory sections, also has a dynamic number of subsections, one for each type of detected episodes for the current measurement period. Each episode section holds information on:

- Number of episodes – number of instances of the episode;
- Total duration – the sum of individual durations of the episode of the type;
- Longest Duration – the episode with the longest duration of the type;
- Maximum HR - the episode with the maximum heart rate of the type;
- Minimum HR - the episode with the minimum heart rate of the type;

5.3. Statistics on Detected Beats and Rhythm Episodes

Detected Beats and their Annotations

The system automatically detects several types of beats, including premature atrial contractions (PAC), premature ventricular contractions (PVC) or fusion beats. They are presented in the specialized section for detected beats (Figure 72), and are also included in the report. The boxes associated for each annotation beat type detected in the report period are similar to those in dashboard.

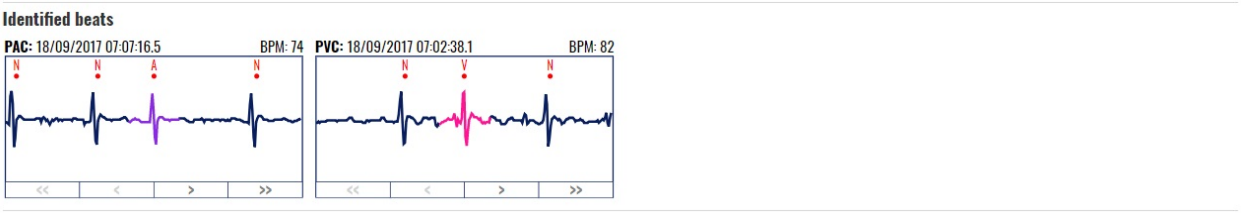

Figure 72: Detected beats and their annotations.

The section displayed for each detected beat type contains an information header (at the top), content box (the main visualization part) and navigation links (bottom part).
The information header contains an abbreviated name of the annotation, an ECG strip of the annotation and navigation buttons bellow the ECG strip (first annotation in the current period, previous annotation, next annotation and last annotation in the current period).
The annotation abbreviation and the annotation ECG strip have as tooltip information on mouse over with the full name of the annotation.
The content box displays a small ECG strip with the annotated beat located in the middle of the box. The beat is colored by the corresponding beat type color.
Navigation buttons contain:

- << show the first annotated beat type in the analyzed report period;
- < show the previous annotated beat type in the analyzed report period;
- > show the next annotated beat type in the analyzed report period;
- >> show the last annotated beat type in the analyzed report period.

A simple navigation is also realized by clicking the annotation strip, which results with a display of an ECG strip for the next annotation of the same type (if next such annotated beat type exists).
The current annotated beat type will be shown when the report is printed or the report is saved and reopened.
A navigation button can be inactive in case such annotation does not exist.

Detected Rhythm Episodes

The system automatically detects several types of rhythm episodes (Figure 73), including Atrial fibrillation (AFIB), ventricular tachycardia (VT), supraventricular tachycardia (SVTA), Bigeminy (B), and Trigeminy (T). They are presented in the specialized section for detected rhythm episodes (Figure 73Figure 72), and are also included in the report. The boxes associated for each rhythm episode detected in the report period are similar to those in dashboard.

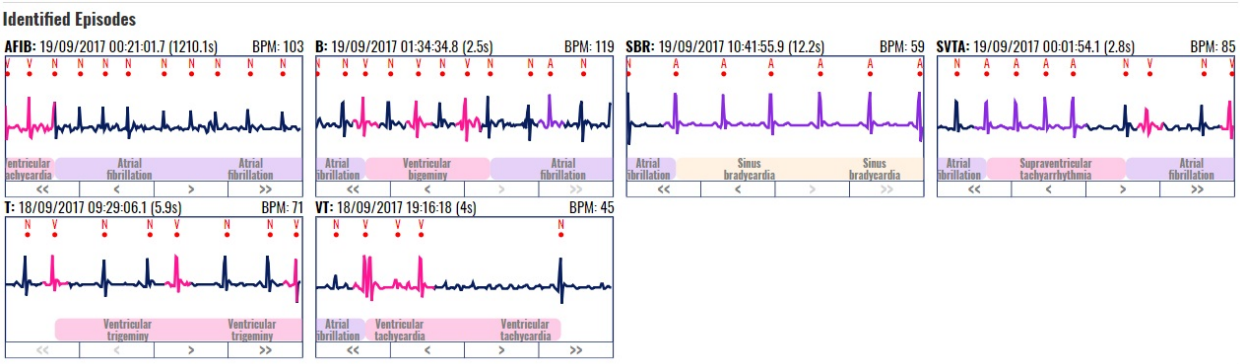

Figure 73: Detected rhythm episodes.

The associated box contains information header, content box and navigation buttons.

The information header contains an abbreviated name of the rhythm episode, the date time stamp when it occurred and duration of the episode, along with the average heart rate calculated for the episode. The episode abbreviation and the episode ECG strip have as tooltip information on mouse over with the full name of the episode.

The main content box displays the ECG strip, such that the beginning of the episode is located at the left (start) of the content box. The signal in the ECG strip is colored according to the beat type colors. The full name of the episode is displayed below the ECG strip in a background color associated to corresponding rhythm episode color.

The navigation buttons bellow the ECG strip enable navigation to the first episode in the analyzed report period (<<), previous episode (<), next episode (>) and last episode (>>).

A navigation button can be inactive in case such episode does not exist.

Navigation is also possible by clicking on the content box of the rhythm episode strip. This results with a display of an ECG strip for the next rhythm episode (if next such episode exists).

The current episode will be shown when the report is printed or the report is saved and reopened.

5.4. Histograms and Selected ECG Strips

Significant Histograms

The report contains a section with significant histograms displayed (Figure 74).

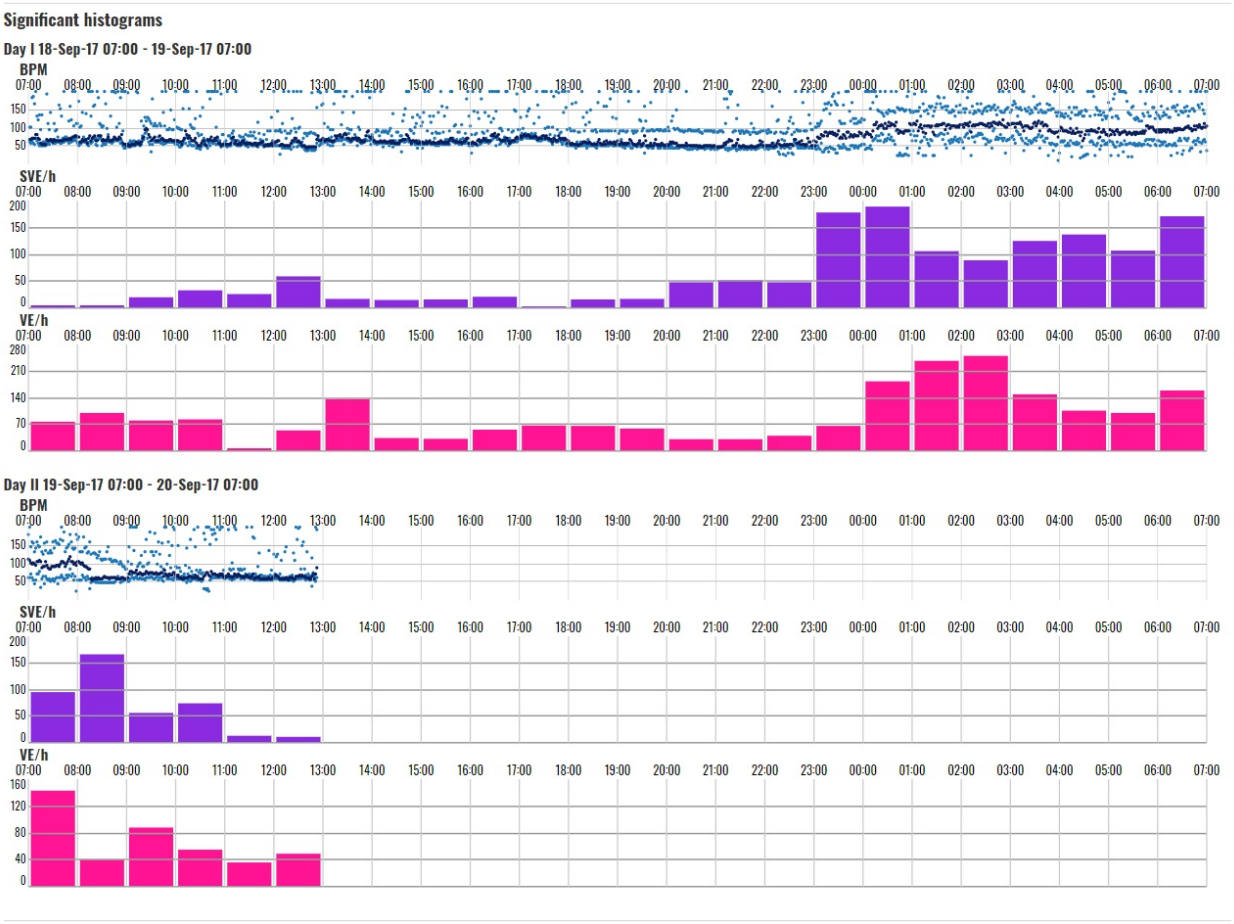

Figure 74: Significant histograms presented in the report.

For each day from the chosen period, a group of histogram charts are rendered:

- BPM (heart rate) chart – a daily heart rate chart is drawn; the visualization resembles the hour selector section from the monitoring section;
- SVE/h - the supraventricular ectopy annotations are grouped together and an hourly column histogram is drawn;
- VE/h - the ventricular ectopy annotations are grouped together and an hourly column histogram is drawn;
- SA/h - hourly column histogram for the sinoatrial arrests;
- MSA/h - hourly column histogram for the micro sinoatrial arrests;

In case all the values in the column histogram are zero, the column histogram is omitted. On mouse over event on the column histogram columns there is tooltip information on the number of the annotation occurrences. The beginning of the time series does not begin at 00:00:00, but it is relative to the start of the first recording period within the day and lasts for 24h.

Selected Segments

The list of selected ECG strip segments by the doctor using the monitoring page is provided in this section. The ECG strips are of duration 7.5s, 15s or 30s. The row is of 7.5s duration, therefore, a strip can span through multiple rows. Each ECG strip is drawn with the standardized ECG grid and it begins with the standard tick symbol.

The doctor can add a comment for each ECG strip. The strip can also be removed from the report by clicking on the accompanied delete button.

5.5. Writing Opinion and File Management

The bottom part of the reporting page contains a text entry field for an expert's opinion and a list of file management action buttons.

Opinion text entry

The form to write an opinion (Figure 75) is presented at the bottom of the page. You need to click with mouse inside this text entry field, and then to start typing a text.

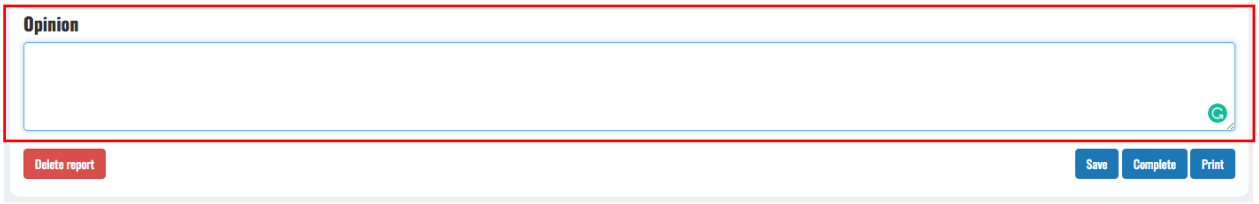

Figure 75: Form to write an opinion in the report.

A click on keyboard key Enter results with a new line (it does not save the text). The file management action buttons are used in order to save the report.

Action Buttons

File management functions for the report are available via action buttons on the bottom of the report page (Figure 76).

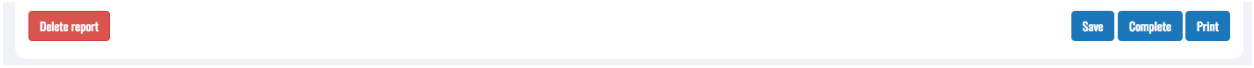

Figure 76: Action buttons for file management.

In the bottom left corner of the page there is an action button "Delete report" which deletes the report contents.
In the bottom right corner of the page there are three action buttons:
Save, which saves the report and prints it immediately afterwards;
Complete, which finalizes the report and stores it in the list of completed reports; and
Print, which is used to print the report in order to give it to the patient.
Note that once you click on complete, the report cannot be changed, it is saved in the list of completed reports. Once the report is completed, you can access it via a list of completed reports, available as a menu option on the main page.
Save is used as an action that can save all entered data for the analyzed patient, and you can continue working on monitoring until the report is completed. This is an option that is frequently used whenever the monitoring is interrupted by other activities.

5.6. Report Printing

Printer dialog form

By clicking the “Print” button the user enters the printing dialogue form (Figure 77).

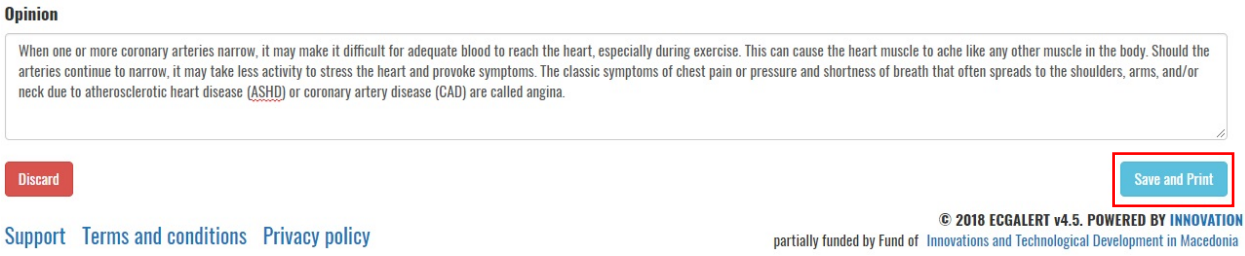

Figure 77: Print button to activate the printing dialogue.

The report dialogue form () is immediately opened after activating the print functionality and the user can choose to print the report to a printer device, save it as a PDF (browser dependent) or export it in another manner (browser and extension dependent).

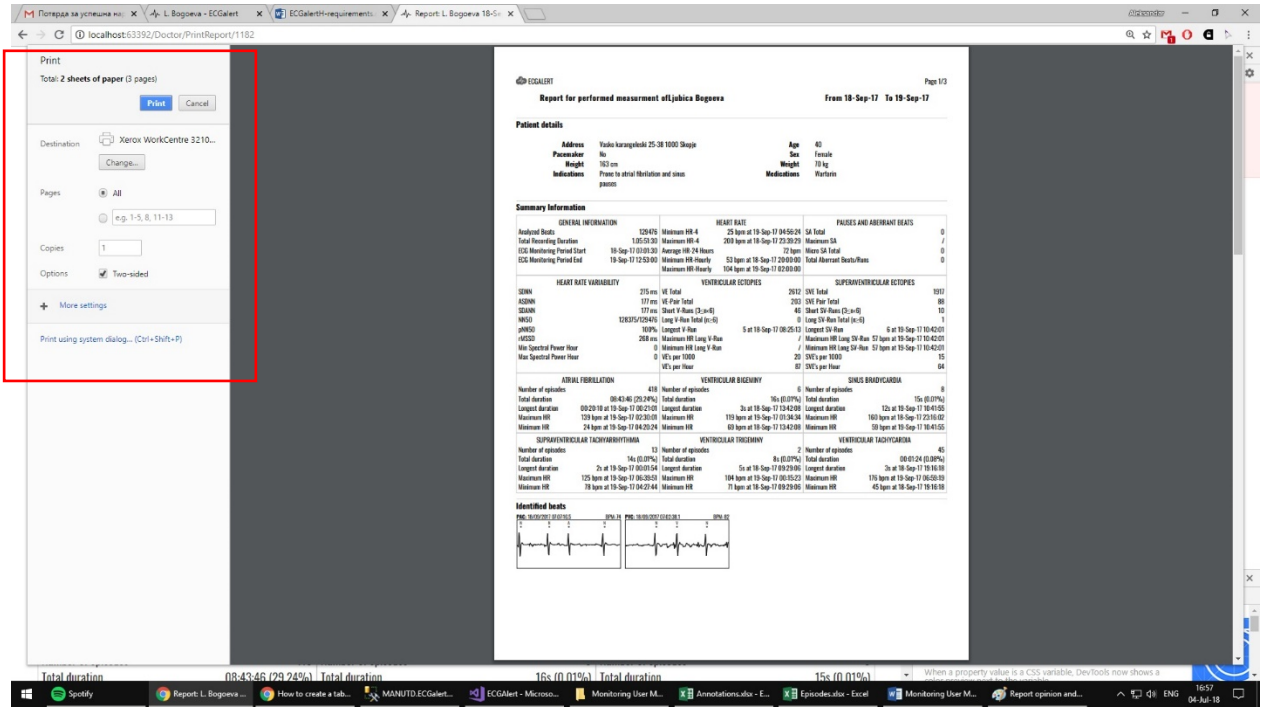

Figure 78: Print dialogue form.

Report page

The print report page resembles the report generation page with a few differences to the report generation/editing page:

- The report generation page header is removed and replaced by a report print page header;
- There are no possibilities for any kind of editing of segment notes, opinion text, adding segments, navigation through detected arrhythmia beats or rhythm episodes;
- The doctor's name and the timestamp of the report creation date can be found below the doctor's opinion section;

ECGALERT Page 1/2

Report for performed measurment of Orson Porter **Period 10/27/2017**

Patient details

Address	588 Hoffman Avenue	**Age**	48
Pacemaker	No	**Sex**	Male
Height	180 cm	**Weight**	61 kg
Indications		**Medications**	

Summary Information

GENERAL INFORMATION		HEART RATE		PAUSES AND ABERRANT BEATS	
Analyzed Beats	2753	Minimum HR-4	80 bpm at 10/27/2017 12:13:55 AM	SA Total	0
Total Recording Duration	00:43:45	Maximum HR-4	153 bpm at 10/27/2017 12:13:54 AM	Maximum SA	/
Normal Sinus Rhythm Duration	00:43:21	Average HR-24 Hours	95 bpm	Micro SA Total	0
ECG Monitoring Period Start	10/27/2017 12:00:00 AM	Minimum HR-Hourly	95 bpm at 10/27/2017 12:00:00 AM	Total Aberrant Beats/Runs	0
ECG Monitoring Period End	10/27/2017 12:29:00 AM	Maximum HR-Hourly	95 bpm at 10/27/2017 12:00:00 AM		

HEART RATE VARIABILITY		VENTRICULAR ECTOPIES		SUPERAVENTRICULAR ECTOPIES	
SDNN	30 ms	VE Total	3	SVE Total	0
ASDNN	9 ms	VE-Pair Total	0	SVE Pair Total	0
SDANN	9 ms	Short V-Runs (3≤n<6)	0	Short SV-Runs (3≤n<6)	0
NN50	2718/2753	Long V-Run Total (n≥6)	0	Long SV-Run Total (n≥6)	0
pNN50	100 %	Longest V-Run	/	Longest SV-Run	/
rMSSD	27 ms	Maximum HR Long V-Run	/	Maximum HR Long SV-Run	/
Min Spectral Power Hour	0	Minimum HR Long V-Run	/	Minimum HR Long SV-Run	/
Max Spectral Power Hour	0	VE's per 1000	1	SVE's per 1000	0
		VE's per Hour	4	SVE's per Hour	0

SUPRAVENTRICULAR TACHYARRHYTHMIA	
Number of episodes	1
Total duration	24s (1.38 %)
Longest duration	24.932032624340 3s at 10/27/2017 12:13:31 AM
Maximum HR	160 bpm at 10/27/2017 12:13:55 AM
Minimum HR	63 bpm at 10/27/2017 12:13:56 AM

Figure 79: Printed report sample and report header.

The report print header is placed on top of every page (Figure 79 and Figure 80) and it contains the following information:

- ECGalert logo;
- Page number indicator;
- Patient full name;
- Measurement period.

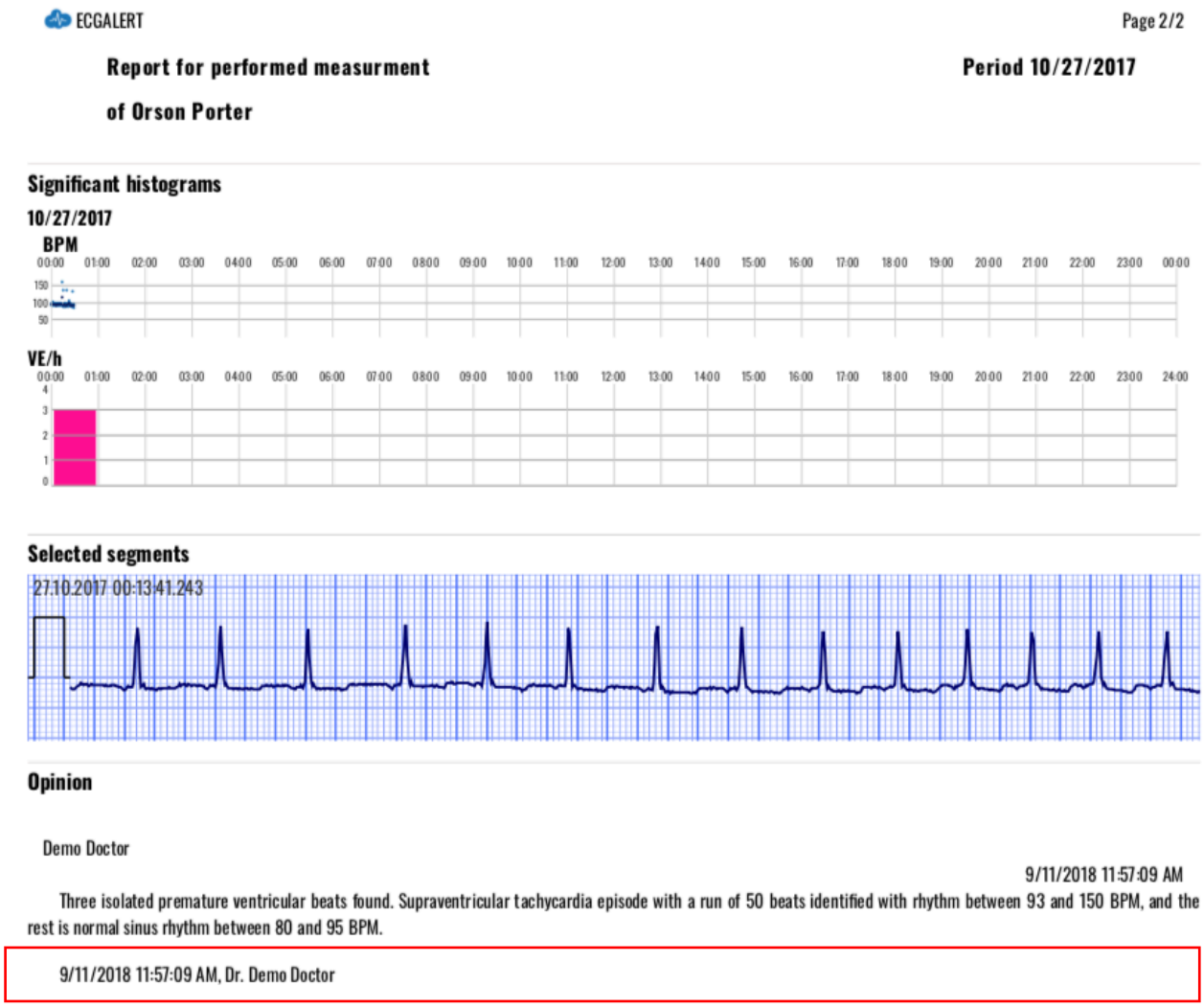

Figure 80: Second page of printed report sample.

The report ends with signature line that contains date time stamp and doctor's name located below the Opinion textual field.