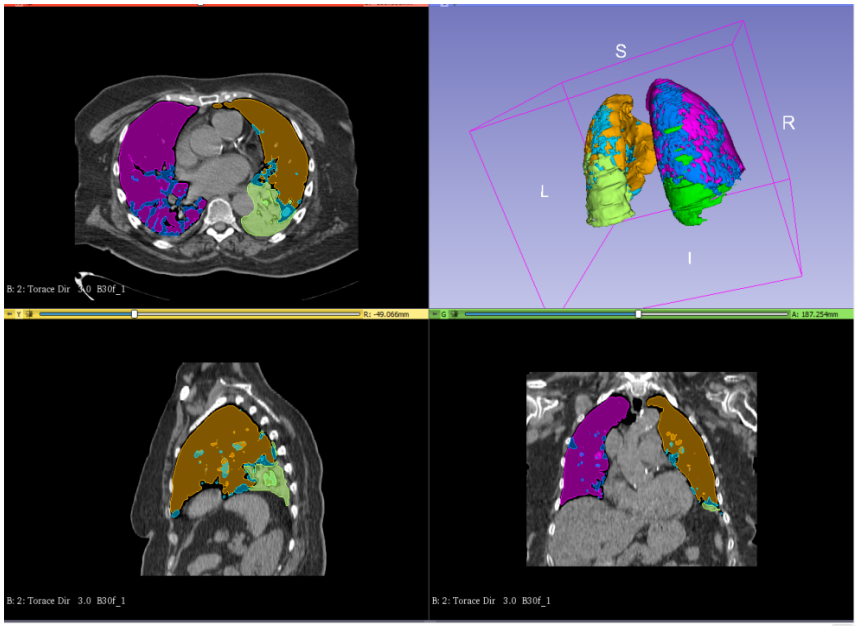
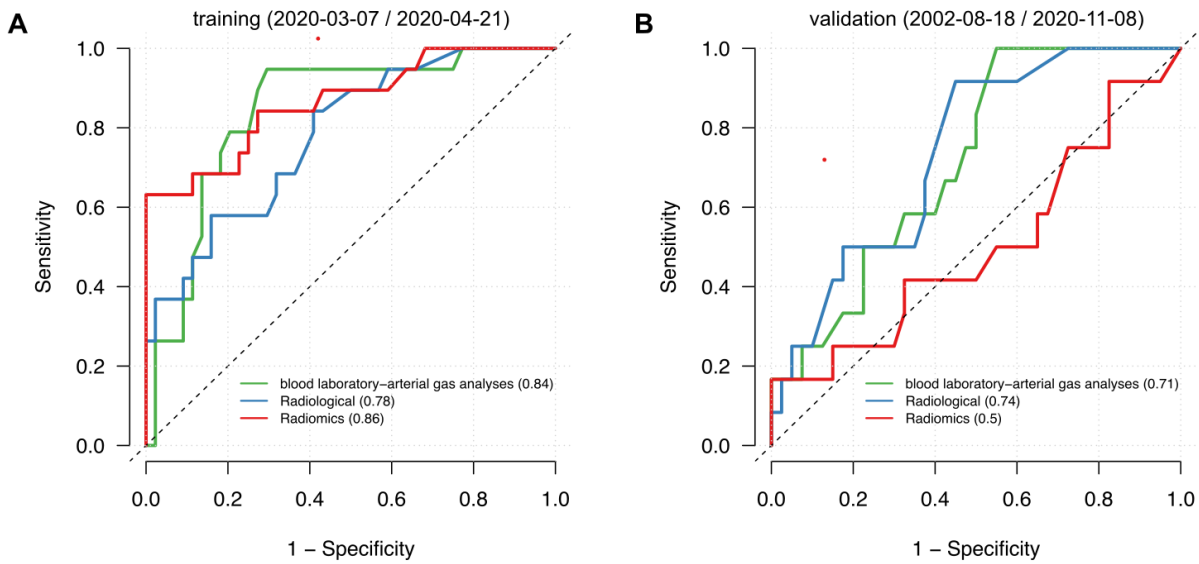
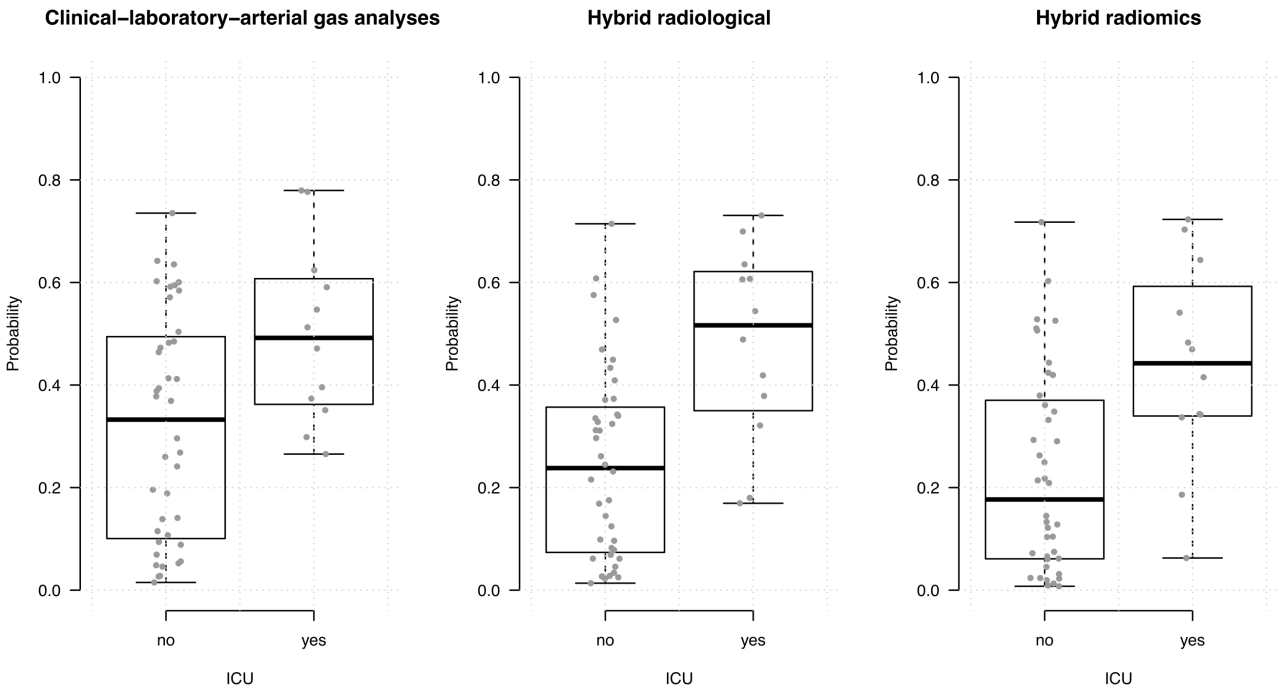



Suppl. Fig. 1 Example of segmentation of CT images. Well-Areated Lung (WAL) area are depicted in purple (right lung) and orange (left lung), Ground Glass Opacities (GGO) area are depicted in blue (right lung) and light blue (left lung) and Consolidation area (Consolid) are depicted in green (right lung) and light green (left lung).




Supplementary Fig. 2. Performance of 3 simple models in predicting ICU admission. Receiving Operating Characteristic (ROC) curve analysis of the blood laboratory-arterial gas analyses features (green line), radiological features (sky blue line) and radiomics features (red line) in the training (A) and validation (B) sets. The values reported in parentheses refer to Area Under the ROC curves.




Supplementary Fig. 3. Box plots of the distribution of the probability of ICU admission estimated using the blood laboratory-arterial gas analyses (left), Hybrid radiological (middle) and Hybrid radiomics (right) models in the patients of the validation set who were not admitted (ICU=no) or required admission (ICU=yes) to ICU. No patient with estimated probability below 0.25 (laboratory-arterial gas analyses model), 0.15 (Hybrid radiology model) and 0.05 (Hybrid radiomic model) required ICU admission.

**Supplementary Table 1.** Radiomic features for image texture analysis extracted using the 3DSlicer software and the module radiomic.

| Parameter type | Parameter name | Description | Selected in Clinical-laboratory-arterial gas analysis | Selected in Radiological | Selected in Radiomics | Selected in Hybrid radiological | Selected in Hybrid radiological + radiomic |
|---|---|---|---|---|---|---|---|
| Clinical-laboratory-arterial gas analysis | Age | years of age at admission to the Emergency Room | X | | | X | |
| Clinical-laboratory-arterial gas analysis | P/F | the Horowitz (P/F) Index is calculated as the ratio between the arterial partial pressure of oxygen [PaO2] measured(in mmHg) by blood gas analysis and fraction of inspired oxygen [FiO2] | X | | | X | X |
| Clinical-laboratory-arterial gas analysis | LDH | serum lactate dehydrogenase (UI/L) | X | | | X | X |
| Clinical-laboratory-arterial gas analysis | D-dimer | D-dimer (µg/mL FEU) | | | | | |
| Clinical-laboratory-arterial gas analysis | PCR | C-Reactive Protein (mg/dL) | | | | | |
| Clinical-laboratory-arterial gas analysis | Lymphocytes | Blood lymphocytes count (103/uL) | | | | | |
| Radiological | % Consolid | corresponds to % of the volume of areas of consolidated lung tissue after manually corrected software segmentation of chest CT images | | X | | X | X |
| Radiological | % Ground Glass | corresponds to % volume of areas of ground glass opacities in the lung after software segmentation of chest CT images | | | | | |
| Radiological | % Normal lung | corresponds to % of the volume of areas of normally areated lung tissue after software segmentation of chest CT images | | X | | | |
| Radiomics | GrayLevelVariance | the variance in gray level intensities for the zones | | | | | |
| Radiomics | HighGrayLevelEmphasis | Measures the distribution of the higher gray-level values, with a higher value indicating a greater concentration of high gray-level values in the image. | | | | | |
| Radiomics | DependenceEntropy | Measures the uncertainty/randomness in dependence. | | | | | |
| Radiomics | DependenceNonUniformity | Measures the similarity of dependence throughout the image, with a lower value indicating more homogeneity among dependencies in the image. | | | X | | |
| Radiomics | GrayLevelNonUniformity | Measures the similarity of gray-level intensity values in the image, where a lower GLN value correlates with a greater similarity in intensity values. | | | | | |
| Radiomics | SmallDependenceEmphasis | A measure of the distribution of small dependencies, with a greater value indicative of smaller dependence and less homogeneous textures. | | | | | |
| Radiomics | SmallDependenceHighGrayLevelEmphasis | Measures the joint distribution of small dependence with higher gray-level values. | | | X | | |

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| Radiomics | DependenceNonUniformityNormalized | Measures the similarity of dependence throughout the image, with a lower value indicating more homogeneity among dependencies in the image. This is the normalized version of the DLN formula. | | | | | |
| Radiomics | LargeDependenceEmphasis | A measure of the distribution of large dependencies, with a greater value indicative of larger dependence and more homogeneous textures. | | | | | |
| Radiomics | LargeDependenceLowGrayLevelEmphasis | Large Dependence Low Gray Level Emphasis (LDLGLE) | | | X | | X |
| Radiomics | DependenceVariance | Measures the variance in dependence size in the image. | | | | | |
| Radiomics | LargeDependenceHighGrayLevelEmphasis | Measures the joint distribution of large dependence with higher gray-level values. | | | | | |
| Radiomics | SmallDependenceLowGrayLevelEmphasis | Measures the joint distribution of small dependence with lower gray-level values. | | | | | |
| Radiomics | LowGrayLevelEmphasis | Measures the distribution of low gray-level values, with a higher value indicating a greater concentration of low gray-level values in the image. | | | | | |
| Radiomics | JointAverage | Returns the mean gray level intensity of the distribution | | | | | |
| Radiomics | SumAverage | Measures the relationship between occurrences of pairs with lower intensity values and occurrences of pairs with higher intensity values. | | | | | |
| Radiomics | JointEntropy | A measure of the randomness/variability in neighborhood intensity values. | | | | | |
| Radiomics | ClusterShade | A measure of the skewness and uniformity of the GLCM. A higher cluster shade implies greater asymmetry about the mean. | | | | | |
| Radiomics | MaximumProbability | Indicates the occurrences of the most predominant pair of neighboring intensity values. | | | | | |
| Radiomics | Idmn | Inverse Difference Moment Normalized is a measure of the local homogeneity of an image. | | | | | |
| Radiomics | JointEnergy | A measure of homogeneous patterns in the image. A greater Energy implies that there are more instances of intensity value pairs in the image that neighbor each other at higher frequencies. | | | | | |
| Radiomics | Contrast | A measure of the local intensity variation, favoring values away from the diagonal i=j. A larger value correlates with a greater disparity in intensity values among neighboring voxels. | | | | | |
| Radiomics | DifferenceEntropy | A measure of the randomness/variability in neighborhood intensity value differences. | | | | | |
| Radiomics | InverseVariance | Assesses variations in intensity of voxels close to each other and therefore quantifies another aspect of homogeneity | | | | | |

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| Radiomics | DifferenceVariance | A measure of heterogeneity that places higher weights on differing intensity level pairs that deviate more from the mean. | | | | | |
| Radiomics | Idn | Inverse Difference Normalized is another measure of the local homogeneity of an image. Unlike Homogeneity1, IDN normalizes the difference between the neighboring intensity values by dividing over the total number of discrete intensity values. | | | | | |
| Radiomics | Idm | Inverse Difference Moment is a measure of the local homogeneity of an image. | | | | | |
| Radiomics | Correlation | Is a value between 0 (uncorrelated) and 1 (perfectly correlated) showing the linear dependency of gray level values to their respective voxels in the GLCM. | | | X | | |
| Radiomics | Autocorrelation | A measure of the magnitude of the fineness and coarseness of texture. | | | | | |
| Radiomics | SumEntropy | A sum of neighborhood intensity value differences. | | | | | |
| Radiomics | SumSquares | A measure in the distribution of neigboring intensity level pairs about the mean intensity level in the GLCM. | | | | | |
| Radiomics | ClusterProminence | Cluster Prominence is a measure of the skewness and asymmetry of the GLCM. A higher values implies more asymmetry about the mean while a lower value indicates a peak near the mean value and less variation about the mean. | | | | | |
| Radiomics | Imc2 | Informational Measure of Correlation 2 assesses the correlation between the probability distributions of i and j (quantifying the complexity of the texture). The range of IMC2 = [0, 1), with 0 representing the case of 2 independent distributions (no mutual information) and the maximum value representing the case of 2 fully dependent and uniform distributions | | | | | |
| Radiomics | Imc1 | Informational Measure of Correlation 1 assesses the correlation between the probability distributions of i and j (quantifying the complexity of the texture), using mutual information I(x, y). In the case where the distributions are independent, there is no mutual information and the result will therefore be 0. In the case of uniform distribution with complete dependence, mutual information will be equal to log2(Ng). Ng=matrix size | | | | | |
| Radiomics | DifferenceAverage | Measures the relationship between occurrences of pairs with similar intensity values and occurrences of pairs with differing intensity values. | | | | | |

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| Radiomics | Id | Inverse Difference is a measure of the local homogeneity of an image. With more uniform gray levels, the denominator will remain low, resulting in a higher overall value. | | | | | |
| Radiomics | ClusterTendency | A measure of groupings of voxels with similar gray-level values. | | | | | |
| Radiomics | InterquartileRange | P75-P25; P25 and P75 are the 25th and 75th percentile of the image array, respectively | | | X | | |
| Radiomics | Skewness | Measures the asymmetry of the distribution of values about the Mean value. Depending on where the tail is elongated and the mass of the distribution is concentrated, this value can be positive or negative. | | | | | |
| Radiomics | Uniformity | A measure of the sum of the squares of each intensity value. This is a measure of the homogeneity of the image array, where a greater uniformity implies a greater homogeneity or a smaller range of discrete intensity values. | | | | | |
| Radiomics | Median | The median gray level intensity within the ROI | | | | | |
| Radiomics | Energy | A measure of the magnitude of voxel values in an image. A larger values implies a greater sum of the squares of these values | | | | | |
| Radiomics | RobustMeanAbsoluteDeviation | The mean distance of all intensity values from the Mean Value calculated on the subset of image array with gray levels in between, or equal to the 10th and 90th percentile | | | | | |
| Radiomics | MeanAbsoluteDeviation | The mean distance of all intensity values from the Mean Value of the image array | | | | | |
| Radiomics | TotalEnergy | The value of Energy feature scaled by the volume of the voxel in cubic mm | | | X | | |
| Radiomics | Maximum | Maximum gray level within the ROI | | | | | |
| Radiomics | RootMeanSquared | The square-root of the mean of all the squared intensity values. It is another measure of the magnitude of the image values. | | | | | |
| Radiomics | 90Percentile | 90th percentile of gray levels within the ROI | | | | | |
| Radiomics | Minimum | Minimum gray level within the ROI | | | | | |
| Radiomics | Entropy | Specifies the uncertainty/randomness in the image values. It measures the average amount of information required to encode the image values | | | | | |
| Radiomics | Range | Range of gray values in the ROI | | | | | |
| Radiomics | Variance | The mean of the squared distances of each intensity value from the Mean value. This is a measure of the spread of the distribution about the mean. | | | | | |
| Radiomics | 10Percentile | 10th percentile of gray levels within the ROI | | | | | |

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| Radiomics | Kurtosis | A measure of the peakedness of the distribution of values in the image ROI. A higher kurtosis implies that the mass of the distribution is concentrated towards the tail(s) rather than towards the mean. A lower kurtosis implies the reverse: that the mass of the distribution is concentrated towards a spike near the Mean value | | | | | |
| Radiomics | Mean | The average gray level intensity within the ROI | | | | | |
| Radiomics | ShortRunLowGrayLevelEmphasis | Measures the joint distribution of shorter run lengths with lower gray-level values. | | | | | |
| Radiomics | LowGrayLevelRunEmphasis | Measures the distribution of low gray-level values, with a higher value indicating a greater concentration of low gray-level values in the image. | | | | | |
| Radiomics | GrayLevelNonUniformityNormalized | Measures the similarity of gray-level intensity values in the image, where a lower GLNN value correlates with a greater similarity in intensity values. This is the normalized version of the GLN formula. | | | | | |
| Radiomics | RunVariance | A measure of the variance in runs for the run lengths. | | | X | | |
| Radiomics | LongRunEmphasis | A measure of the distribution of long run lengths, with a greater value indicative of longer run lengths and more coarse structural textures. | | | | | |
| Radiomics | ShortRunHighGrayLevelEmphasis | Measures the joint distribution of shorter run lengths with higher gray-level values. | | | | | |
| Radiomics | RunLengthNonUniformity | Measures the similarity of run lengths throughout the image, with a lower value indicating more homogeneity among run lengths in the image. | | | | | X |
| Radiomics | ShortRunEmphasis | A measure of the distribution of short run lengths, with a greater value indicative of shorter run lengths and more fine textural textures. | | | | | |
| Radiomics | LongRunHighGrayLevelEmphasis | Measures the joint distribution of long run lengths with higher gray-level values. | | | | | |
| Radiomics | RunPercentage | Measures the coarseness of the texture by taking the ratio of number of runs and number of voxels in the ROI. Values are in range Np<=RP<=1, with higher values indicating a larger portion of the ROI consists of short runs (indicates a more fine texture). Np be the number of voxels in the image | | | | | |
| Radiomics | LongRunLowGrayLevelEmphasis | Measures the joint distribution of long run lengths with lower gray-level values. | | | | | |
| Radiomics | RunEntropy | Measures the uncertainty/randomness in the distribution of run lengths and gray levels. A higher value indicates more heterogeneity in the texture patterns. | | | | | |

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| Radiomics | HighGrayLevelRunEmphasis | Measures the distribution of the higher gray-level values, with a higher value indicating a greater concentration of high gray-level values in the image. | | | | | |
| Radiomics | RunLengthNonUniformityNormalized | Measures the similarity of run lengths throughout the image, with a lower value indicating more homogeneity among run lengths in the image. This is the normalized version of the RLN formula. | | | | | |
| Radiomics | ZoneVariance | Measures the variance in zone size volumes for the zones. | | | | | |
| Radiomics | SizeZoneNonUniformityNormalized | Measures the variability of size zone volumes throughout the image, with a lower value indicating more homogeneity among zone size volumes in the image. This is the normalized version of the SZN formula. | | | | | |
| Radiomics | SizeZoneNonUniformity | Measures the variability of size zone volumes in the image, with a lower value indicating more homogeneity in size zone volumes. | | | | | |
| Radiomics | LargeAreaEmphasis | A measure of the distribution of large area size zones, with a greater value indicative of more larger size zones and more coarse textures. | | | | | |
| Radiomics | SmallAreaHighGrayLevelEmphasis | Measures the proportion in the image of the joint distribution of smaller size zones with higher gray-level values. | | | | | |
| Radiomics | ZonePercentage | Measures the coarseness of the texture by taking the ratio of number of zones and number of voxels in the ROI. | | | | | |
| Radiomics | LargeAreaLowGrayLevelEmphasis | Measures the proportion in the image of the joint distribution of larger size zones with lower gray-level values. | | | X | | |
| Radiomics | LargeAreaHighGrayLevelEmphasis | Measures the proportion in the image of the joint distribution of larger size zones with higher gray-level values. | | | | | |
| Radiomics | HighGrayLevelZoneEmphasis | Measures the distribution of the higher gray-level values, with a higher value indicating a greater proportion of higher gray-level values and size zones in the image. | | | | | |
| Radiomics | SmallAreaEmphasis | A measure of the distribution of small size zones, with a greater value indicative of more smaller size zones and more fine textures. | | | | | |
| Radiomics | LowGrayLevelZoneEmphasis | Measures the distribution of lower gray-level size zones, with a higher value indicating a greater proportion of lower gray-level values and size zones in the image. | | | | | X |
| Radiomics | ZoneEntropy | Measures the uncertainty/randomness in the distribution of zone sizes and gray levels. A higher value indicates more heterogeneneity in the texture patterns. | | | | | |

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|---|---|---|---|---|---|---|---|
| Radiomics | SmallAreaLowGrayLevelEmphasis | Measures the proportion in the image of the joint distribution of smaller size zones with lower gray-level values. | | | X | | |
| Radiomics | Coarseness | A measure of average difference between the center voxel and its neighbourhood and is an indication of the spatial rate of change. A higher value indicates a lower spatial change rate and a locally more uniform texture. | | | | | |
| Radiomics | Complexity | An image is considered complex when there are many primitive components in the image, i.e. the image is non-uniform and there are many rapid changes in gray level intensity. | | | | | |
| Radiomics | Strength | Strength is a measure of the primitives in an image. Its value is high when the primitives are easily defined and visible, i.e. an image with slow change in intensity but more large coarse differences in gray level intensities. | | | | | |
| Radiomics | Busyness | A measure of the change from a pixel to its neighbour. A high value for busyness indicates a busy image, with rapid changes of intensity between pixels and its neighbourhood. | | | | | |