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Prediction of Severity Prognosis in COVID-19 patients using Machine Learning

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Abstract: Our Invention Machine Learning Model for Predicting Severity Prognosis in Patients Infected with COVID-19.cis to the new coronavirus, that began to be known as SARS-CoV-2, could be a fiber polymer beta coronavirus, at first known in metropolis (Hubei province, China) and presently spreading across six continents inflicting a substantial hurt to patients, with no specific tools as yet to produce prognostic outcomes. The Invention is to gauge potential findings on chest CT of patients with signs and symptoms of metabolic process syndromes and positive epidemiologic factors for COVID-19 infection and to correlate them with the course of the sickness. During this sense, it's conjointly expected to develop specific machine learning formula for this purpose, through pneumonic segmentation, which may predict potential prognostic factors, through a lot of correct results. Our various hypotheses is that the machine learning model supported clinical, tomography and epidemiologic information are going to be able to predict the severity prognosis of patients infected with COVID-19. we'll perform a multicenter retrospective longitudinal study to get an outsized variety of cases in a very short amount of your time, for higher study validation.
Keyword: Machine Learning, Model, Predicting, Severity, Prognosis, Patients, Infected, COVID-19.

RESEARCH BACKGROUND

[002] The first coronaviruses discovered within the world were to blame for metabolism and internal organ infections, of that the overwhelming majority had an end course and semiconductor diode largely to symptoms of respiratory disorder.

[003] However, they'll eventually transform serious infections in teams in danger (heart diseases, diabetes, among others), within the senior and additionally in youngsters. Before the start of this current pandemic, 2 extremely infective coronavirus species (SARS and MERS) were delineated and were to blame for outbreaks of severe acute metabolism syndrome.

[004] Regarding this new coronavirus (COVID-19) it had been recognized as a motive agent of respiratory disorder that ends up in severe acute metabolism syndrome (SARS-CoV-2).

[005] One among its main challenges is its fast transmission capability and, in some cases, progression to severe pneumonic conditions that have demanded from the health system a care and combat strategy ne'er seen before within the whole world.

[006] In Brazil, the expectation is to be of exponential growth, that is why there's a necessity to implement forceful measures to manage population circulation and hindrance.
[007] Because of the speed of transmission, in most countries, as well as Brazil, early-stage preventive measures weren't enforced, inflicting AN explosion of symptomatic cases, several of them severe, with prolonged demand from tertiary health services.

[008] Given this situation, the inevitable emergence of an outsized contingent of critically unwell patients with COVID-19, with completely different prognoses, created it crucial to go looking for early diagnostic mechanisms for higher screening and treatment adequacy in every case.

[009] The during this context, even before confirmation of the infection, screening for patients with metabolism symptoms is administered through clinical analysis and imaging tests like Chest CT (CT).

[010] In clinical analysis, the most delineated symptoms of infection are fever (88.5%), cough (68.6%), hurting or fatigue (35.8%), sputum (28, 2%) and dyspnea (21.9%). alternative symptoms additionally delineated embody headache and symptom (12.1%), diarrhea (4.8%), nausea and unconditioned reflex (3.9%).

[011] The additionally, some medicine changes were observed: blood disorder (64.5%), enhanced C-reactive protein (CRP) (44.3%), enhanced potable dehydrogenase (DHL) (28.3%), and blood disorder (29, 4%).

[012] Chest CT is considering because the best imaging technique for assessment of COVID-19, since typical radiography has low sensitivity, notably in early stages.

[013] Typical findings delineated within the literature embody ground-glass opacities (GGO) with a lot of peripheral distribution, related to septate thickening and consolidations, typically moving multiple lobes, though these findings also can be found in alternative infectious agent pneumonias.

RESEARCH OBJECTIVES

1) The objective of the invention is to a evaluate possible changes in Chest CT, through a score, that suggest a worse prognosis in patients with COVID-19.
2) The other objective of the invention is to a identify patterns correlated with worse clinical developments, to guide, in the prospective unfolding of the study.
3) The other objective of the invention is to a prognostic markers arising automated analyses of Chest CT and contribute to prioritizing treatment according to severity (or tracheal intubation, hospitalization).
4) The other objective of the invention is to a Organize a database with medical images and their respective anonymized reports for CT modality, in different morph-functional changes, in patients with acute respiratory syndromes.
5) The other objective of the invention is to a Evaluate the performance of AI algorithms in this data for tasks such as classification, segmentation, image registration and interpretation of reports.

6) The other objective of the invention is to a Evaluate the impact of the use of these models on medical practice of imaging professionals.

RESEARCH SUMMARY

Data Availability:

[014] The information cannot be created in public accessible as a result of only 1 establishment had American stature IRB approval to share data in public (Universidad Federal de Sao Paulo - Unifies), as this establishment has technical means that already in situ to sufficiently redact patient information to permit public sharing.

[015] The IRBs in different establishments Universidad do Estado do First State Janeiro de Janeiro, Hospital nine Diamond State Julio, Hospital São George Lucas, Hospital Santa Paula, and Hospital Alamo Oswaldo Cruz) enable studies to be conducted inside establishments, however to not share information in public thanks to probably distinguishing.
[016] The sensitive patient info, even if the information is de-identified. information access queries could also be directed to Fernandez Rodrigues dos Santos.

Funding:

[017] This study was funded by Diagnostics prosecuting officer América (DASA). The funder provided support within the style of salaries for authors FPPLL, FCK, PEAK, MRTG, VPSR, MRFM, RZP, RASO, LGPD, PRTPD.
[018] RVO, however didn't have any further role within the study style, information assortment and analysis, call to publish, or preparation of the manuscript. the particular roles of those authors area unit articulated within the 'author contributions' section.

Competing interests:

[019] The authors have scanned the journal's policy and have the subsequent potential competitive interests: FPPLL has received support for participation in courses and symposia from analgesic, and for scientific practice and lectures for analgesic.
[020] The Novartis. GS has received support for participation in courses and symposia for analgesic, and costs for Lectures in Cardiothoracic Imaging for analgesic, Novartis, and Amgen.

[021] FCK may be a paid worker of Diagnostics prosecuting officer América (DASA) and an authority for MD.ai. GFP has received support for participation in courses and symposia from Boehringer-Ingelheim, AstraZeneca and port Myers Squibb.

[022] The scientific practice and lectures from Boehringer-Ingelheim, AstraZeneca, Pfizer, port Myers Squibb, Merck Sharpe & Dohme. VPSR and MRFM area unit paid workers of DASA.
[024] This doesn't alter our adherence to PLOS ONE policies on sharing information and materials. There aren't any patents, merchandise in development or marketed merchandise related to this analysis to declare.

Algorithm development and AI data evaluation

Data set:

[025] The info set can contain Chest CT performed in laboratories happiness to the arranger Centre network and partner establishments. Radiologists can annotate a part of this set of exams, every annotation are composed of a plane figure that segments the respiratory organ in each slice of the computerized tomography.

[026] every coaching instance can then contain a slice of a computerized tomography communicating (entry to the model) and also the plane figure that separates the respiratory organ (expected response from the model).

[027] It ought to be noted that the development of the algorithmic rule is performed at the arranger Centre.

[028] The coaching of the segmentation model can occur during a supervised manner, mistreatment the annotated set of knowledge, wherever every instance of this set should have a plane figure that delimits the region pertaining to the respiratory organ within the communicating.

[029] We are going to use the segmentation model to calculate the respiratory organ volumes and percentages of GGO and consolidations within the non-annotated Chest CT.

[030] This info, in conjunction with clinical and laboratorial knowledge, can give knowledge to develop a machine learning model that predicts the first and secondary outcomes.

[031] For all models, we are going to solely think about patients that either died or were discharged. For primary and secondary outcomes analysis, we are going to exclude the unknown cases. we are going to compare totally different classification models, like lightweight GBM and Cat boost.

[932] Cat Boost may be a model from the family of gradient boosting trees. though powerful, gradient boosting trees tend to overfit the coaching knowledge once fed with too several options, that's why we tend to restricted the number of options to be studied during this protocol.

[031] We are going to additionally limit the depth of the trees to 3 and fix the educational rate at zero.01 and also the patience for early stopping at fifty epochs.

[032] The primary metric is that the space beneath the receiver operative graphical record (AUC—ROC). for every model, we are going to separate 2 hundredth of the thought-about patients to create our take a look at set.

[033] On the opposite eightieth, we are going to run a 5-fold cross-validation, and every one of our results can have a mean and a typical deviation on the holdout patients. These algorithms are evaluated mistreatment numerous performance metrics (sensitivity, specificity, positive and negative prophetical values.

[034] The generalization of leads to our population, and also the performance in relevancy effectiveness, safety and quality. we are going to calculate F1 and accuracy for all thresholds, and choose the most effective threshold.

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RESEARCH BRIEF DESCRIPTION OF THE DIAGRAM

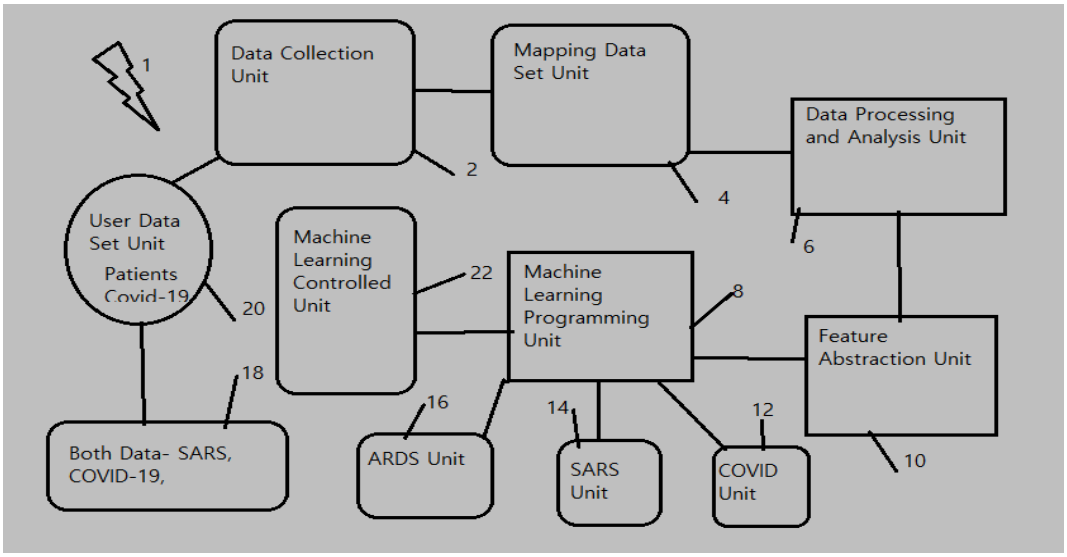

FIG.1: Machine Learning Model for Predicting Severity Prognosis in Patients Infected with COVID-19.

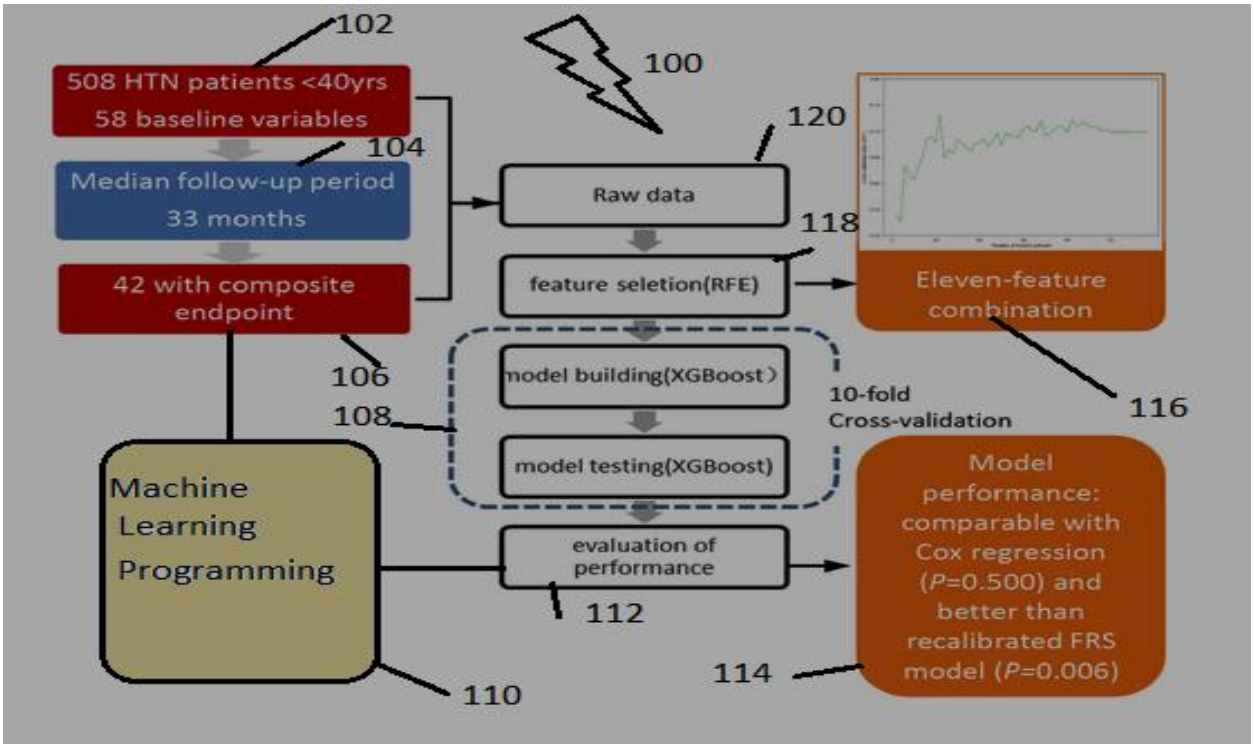

Fig.2: Machine Learning Model for Predicting Severity.

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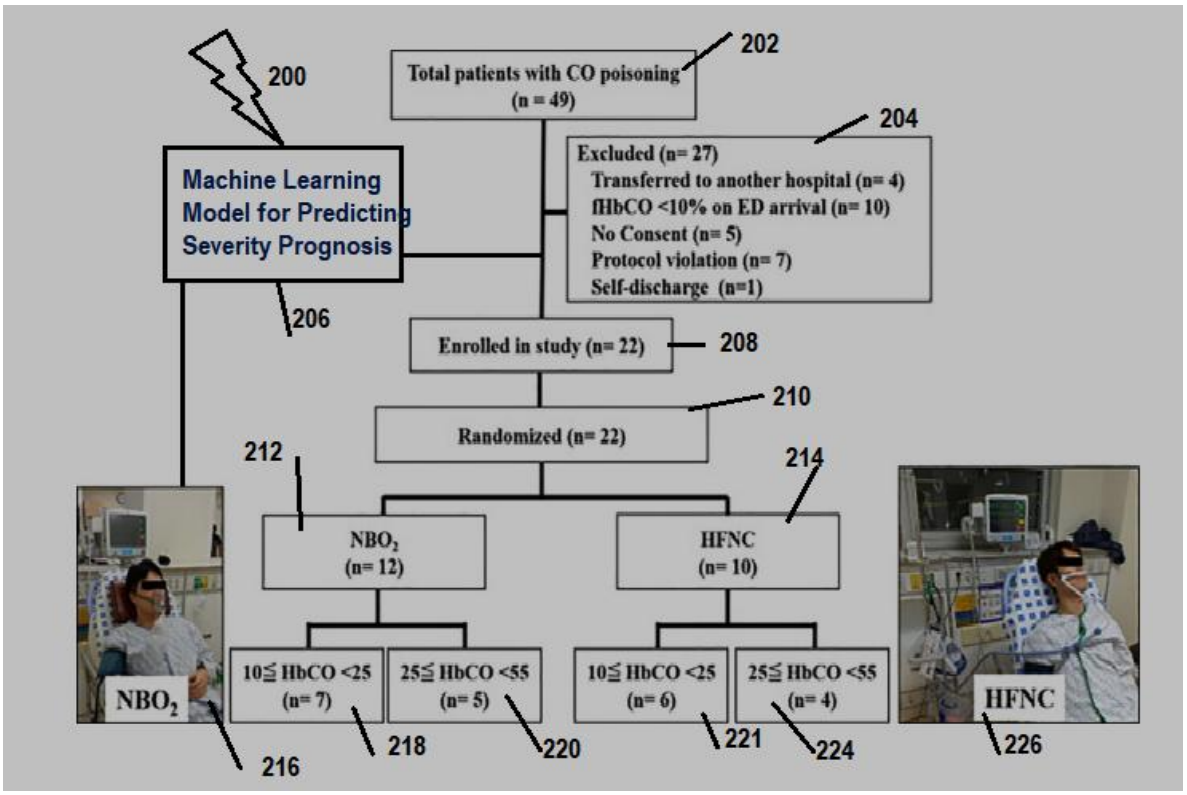

Fig.3: Model for Predicting Severity Prognosis flow chart.

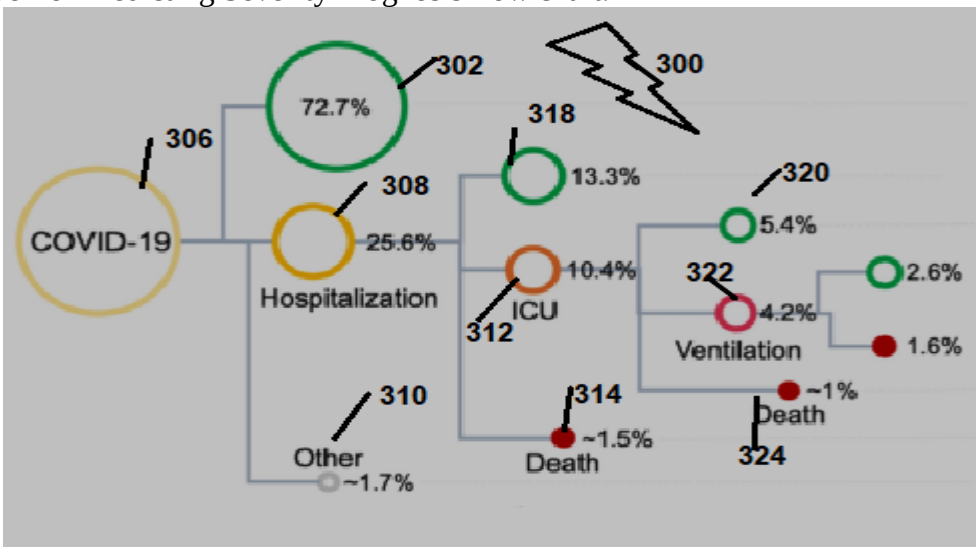

FIG.4: Predicting Severity Prognosis in Patients Infected with COVID-19. block diagram.

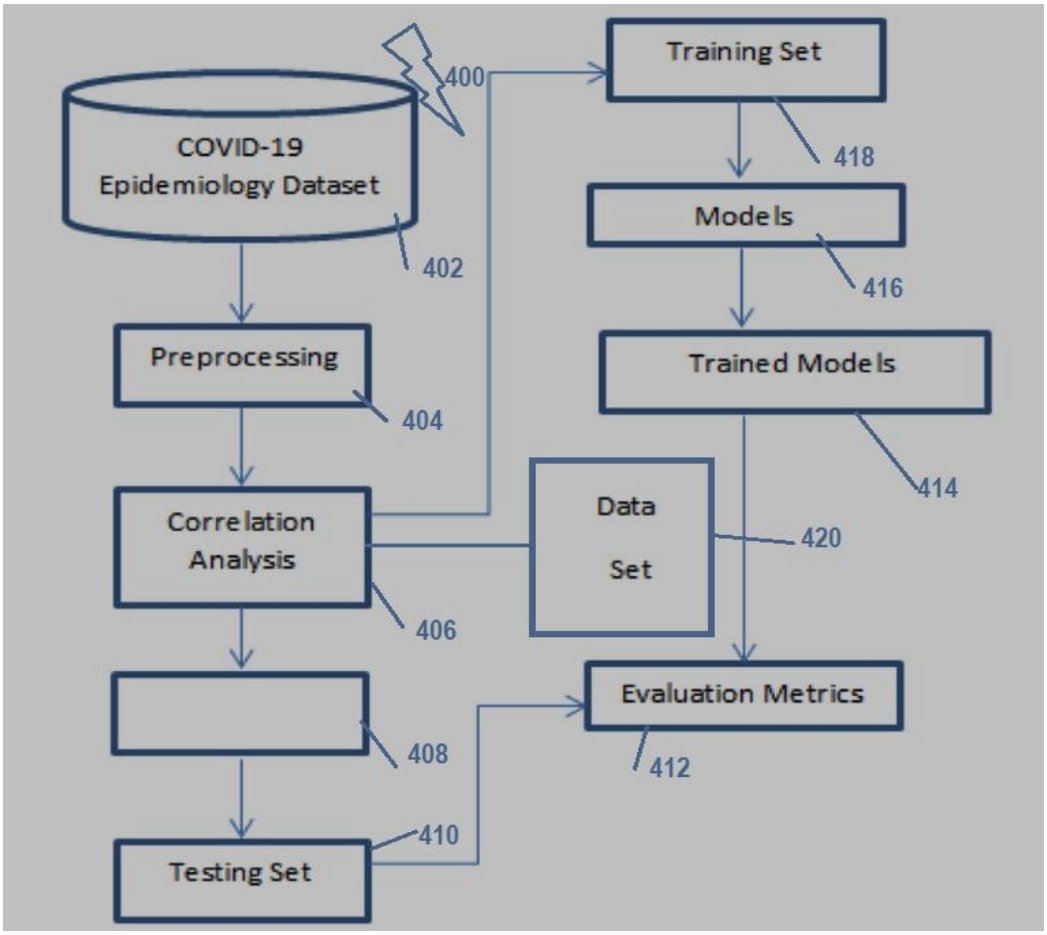

Fig.5: Machine Learning Model for Predicting Severity Prognosis in Patients Infected with COVID-19. Complete Process.

RESEARCH DESCRIPTION OF THE INVENTION

Materials and methods

[035] We will conduct a retrospectively longitudinal multicentre study (9 Institutions) with a minimum of one hundred sixty patients hospitalized from March to mite 2020 thanks to clinical signs and symptoms of acute metastasis syndrome.

[036] This invention was approved by our National commission (CONEP and approved across every taking part centre's commission de Janeiro, Universidad do Estado do Diamond State de Janeiro, Universidad Federal DE Sao Paulo, Hospital nine DE Julio, Hospital São film maker, Hospital Santa Paula, Hospital Alamo Oswaldo Cruz).

[037] CONEP is that the central commission. we have a tendency to requested relinquishing of the consent kind thanks to the retrospective study style.

Study population

[038] Eligible patients for the study should meet the subsequent characteristics are thought-about eligible for the study:

1. Signs and symptoms of acute metastasis syndrome

2. Positive medicine history for COVID-19, which can embody recent contact (last fourteen days) with a confirmed or suspected case, recent trip (last fourteen days) to a high-incidence location, or presentation of symptoms once the beginning of the community transmission section of SARS-CoV-2 (after 3/20/2020) once the date of hospitalization.
3. Have performed, once symptomatic, a chest CT.

Exclusion criteria

1. Presence of growth (primary or metastatic) respiratory organ lesions, manifested as nodules, masses, consolidations, body part thickening (lymphatic carcinomatosis) or serosa thickening;
2. Chest CT with the presence of movement, acquisition or reconstruction artefacts that build it not possible to use the segmentation algorithms;
3. CT exams with calibre respiratory organ segmentation, or slice thickness larger than three.0 mm.

Composition of study outcomes

[039] The definition of the outcomes of this study were:Primary outcomes
1. Time to hospital discharge (length of keep, LOS), outlined because the amount (in days) between the date of admission and therefore the date of discharge (or death);
2. Length of keep within the social unit (ICU LOS), outlined because the amount (in days) marches on between admission and discharge (or death) from the ICU;
3. Orotracheal cannulisation because of acute metabolic process failure;
4. Development of acute metabolic process discomfort syndrome.
Secondary outcomes
1. Sepsis.
2. cardiovascular disease or cardiocirculatory disfunction requiring the prescription of vasopressors or inotropes.
3. Coagulopathy.
4. Acute infarct.
5. Acute kidney disease [20].
6. Death

[040] We will use the AUC and F1-score of those algorithms because the main metrics, and that we hope to spot algorithms capable of generalizing their results for every such primary and secondary outcomes.

Sample size calculation

[041] One in every of the most queries are to verify whether or not Chest CT could be a great tool as a predictor of severity and worst evolution of COVID-19 respiratory disease.

[042] Recent studies employing a similar methodology showed that the Chest CT scores showed a distinction of roughly seventeen.3 points within the average for the scores between the "Survival group" and "Mortality group" among hospitalized patients infected with COVID-19.
[043] During this previous study, the pooled variance of the teams, that were some seventeen.5, leading to an impact size of zero.99.

[045] To knowledge several patients with "favourable clinical outcome" and with additional "severe outcomes" we'd have to be compelled to have. As we have a tendency to expect additional patients within the "favourable clinical outcome" cluster, we have a tendency to created our sample size calculation considering a 3:1 quantitative relation.

[046] If actuality distinction among teams suggests that in our study is seventeen.3 CT score points, we {are going to} have to be compelled to study a minimum of fifteen cases within the "severe outcome" cluster and forty-five management subjects within the "favourable outcome" cluster to be able to reject the null hypothesis that the population suggests that of each teams are equal with chance (power) of zero,9.

[047] The kind I error chance related to this take a look at of this null hypothesis is zero.05.We'll assess chest CT of those patients and to correlate them with the course of the sickness. Primary outcomes:
1) Time to hospital discharge;
2) Length of keep within the ICU;
3) orotracheal intubation;
4) Development of Acute metabolic process Discomfort Syndrome. Secondary outcomes:
1) Sepsis;
2) cardiovascular disease or cardiocirculatory dysfunction requiring the prescription of vasopressors or inotropes;
3) Coagulopathy;
4) Acute cardiac muscle Infarction;
5) Acute nephritic Insufficiency;
6) Death. we'll use the terrorist organization and F1-score of those algorithms because the main metrics, and that we hope to spot algorithms capable of generalizing their results for every fixed primary and secondary outcome.

[048] Fig.2: Machine Learning Model for Predicting Severity: The **MachineLearning** model supported clinical, imaging and medicine knowledge are able to determine imaging and clinical factors related to illness severity, and presumably estimate prognosis (hospitalization desires, unit admission, orotracheal intubation), particularly in pandemic times.

[049] The new coronavirus, that began to be referred to as SARS-CoV-2, may be a fiber polymer beta coronavirus, at first known in urban center (Hubei province, China) and presently spreading across six continents inflicting a substantial hurt to patients, with no specific tools thus far to supply prognostic outcomes.

[050] Thus the aim of this study is to judge potential findings on chest CT of patients with signs and symptoms of metabolic process syndromes and positive epidemiologic factors for COVID-19 infection and to correlate them with the course of the sickness.

[051] The during this sense, it's conjointly expected to develop specific machine learning algorithmic program for this purpose, through pulmonic segmentation, which might predict potential prognostic factors, through a lot of correct results.

[052] Our various hypothesis is that the machine learning model supported clinical, imaging and epidemiologic information are going to be ready to predict the severity prognosis of patients infected with COVID-19.

[053] The we are going to perform a multicenter retrospective longitudinal study to get an oversized variety of cases in a very short amount of your time, for higher study validation.

[054] Our convenience sample (at least twenty cases every are going to be collected in each center considering the inclusion and exclusion criteria. we are going to assess patients United Nations agency enter the hospital with clinical signs and symptoms of acute metabolic process syndrome, from March to mite 2020.

[055] we are going to embrace people with signs and symptoms of acute metabolic process syndrome, with positive epidemiologic history for COVID-19, United Nations agency have performed a chest X-radiation. we are going to assess chest CT of those patients and to correlate them with the course of the sickness. Primary outcomes:
1) Time to hospital discharge;
2) Length of keep within the ICU;
3) orotracheal intubation;
4) Development of Acute metabolic process Discomfort Syndrome.

Secondary outcomes:
1) Sepsis;
2) cardiovascular disease or cardiocirculatory dysfunction requiring the prescription of vasopressors or inotropes;
3) Coagulopathy;
4) Acute cardiac muscle Infarction;
5) Acute urinary organ Insufficiency;
6) Death. we are going to use the Antidefense Unidos de Colombia and F1-score of those algorithms because the main metrics, and that we hope to spot algorithms capable of generalizing their results for every mere primary and secondary outcome.

Fig.3: Model for Predicting Severity Prognosis flow chart.:
[056] The novel coronavirus unwellness 2019 (covid-19) presents a crucial and pressing threat to international health. Since the irruption in early Dec 2019 within the Hubei province of the People's Republic of China, the quantity of patients confirmed to possess the unwellness has exceeded forty-seven million because the unwellness unfold globally.
[[057] The variety of individuals infected is maybe abundant higher. over one.2 million individuals have died from covid-19 (up to three Nov two020). Despite public health responses aimed toward containing the unwellness and delaying the unfold, many countries are confronted with a crucial care crisis, and additional countries may follow.
[058] Outbreaks result in vital will increase within the demand for hospital beds and absence of medical instrumentality, whereas medical employees themselves may become infected.

[059] The many regions have had or square measure experiencing second waves, and despite enhancements in testing and tracing, many regions square measure once more facing the boundaries of their take a look at capability, hospital resources and attention employees.

FIG.4: Predicting Severity Prognosis in Patients Infected with COVID-19. diagram.

[060] We retrospectively analyzed 123 antecedently healthy young adults diagnosed with COVID-19 from Gregorian calendar month to March 2020 in an exceedingly tertiary hospital in city.

[061] Patients were classified as having delicate or severe COVID-19 supported their rate of respiration, SpO2, and PaO2/FiO2 levels. Patients' symptoms, pc pictorial representation (CT) pictures, preadmission medication received.

[062] The body fluid organic chemistry examination on admission were compared between the delicate and severe teams. vital variables were registered into logistical regression model to predict the factors touching unwellness severity.

[063] A receiver operational characteristic (ROC) curve was applied to validate the prognostic worth of predictors.
[064] Age; temperature; anorexia; and white blood corpuscle count, white blood cell proportion, protoplasm count, white corpuscle count, C-reactive protein, aspartate transferase, amino acid enzyme, albumin.
[065] The factor I values were considerably totally different between patients with delicate and severe COVID-19 ($P < 0.05$). logistical multivariate analysis confirmed that lymphocytopenia ($P = 0.010$) indicated severe prognosis in antecedently healthy young adults with COVID-19, with the realm beneath the curve (AUC) was zero.791(95% Confidence Interval (CI) zero.704–0.877) ($P < 0.001$).
[066] FIG.5: COVID-19 or 2019-nCoV is not any longer pandemic however rather endemic, with over 651,247 individuals around world having lost their lives once catching the malady. Currently, there's no specific treatment or cure for COVID-19.

[067] The living with the malady and its symptoms is inevitable. This reality has placed a colossal burden on restricted attention systems worldwide particularly within the developing nations. though neither an efficient, clinically proved.

[068] Associate in Nursingtiviral agents' strategy nor an approved immunizing agent exist to eradicate the COVID-19 pandemic, there are a unit alternatives that will cut back the large burden on not solely restricted attention systems however conjointly the economic sector.

[069] The foremost promising embrace harnessing non-clinical techniques like machine learning, data processing, deep learning and alternative AI. These alternatives would facilitate designation and prognosis for 2019-nCoV pandemic patients.

[070] The supervised machine learning models for COVID-19 infection were developed during this work with learning algorithms that embrace logistical regression, call tree, support vector machine, naive Bayes, and artificial neutral network victimization medical specialty tagged dataset for positive and negative COVID-19 cases of North American country.

[071] The coefficient of correlation analysis between numerous dependent and freelance options was dole out to work out a strength relationship between every dependent feature and freelance feature of the dataset before developing the models.

[072] The eightieth of the coaching dataset was used for coaching the models whereas the remaining two hundredth were used for testing the models.

[073] The results of the performance analysis of the models showed that call tree model has the very best accuracy of ninety-four.99% whereas the Support Vector Machine Model has the very best sensitivity of ninety-three.34% and Naïve Bayes Model has the very best specificity of ninety-four.30%.

[074] Our convenience sample at least twenty cases every going to be collected in each center considering the inclusion and exclusion criteria.

[075] we'll assess patients World Health Organization enter the hospital with clinical signs and symptoms of acute metabolic process syndrome, from March to could 2020. we'll embody people with signs and symptoms of acute metabolic process syndrome, with positive epidemiologic history for COVID-19, World Health Organization have performed a chest CAT.

RESEAR CH CLAIMS

1) Our Invention Machine Learning Model for Predicting Severity Prognosis in Patients Infected with COVID-19.cis to the new coronavirus, that began to be known as SARS-CoV-2, could be a fiber polymer beta coronavirus, at first known in metropolis (Hubei province, China) and presently spreading across six continents inflicting a substantial hurt to patients, with no specific tools as yet to produce prognostic outcomes. The Invention is to gauge potential findings on chest CT of patients with signs and symptoms of metabolic process syndromes and positive epidemiologic factors for COVID-19 infection and to correlate them with the course of the sickness. during this sense, it's conjointly expected to develop specific machine learning formula for this purpose, through pneumonic segmentation, which may predict potential prognostic factors, through a lot of correct results. Our various hypothesis is that the machine learning model supported clinical, tomography and epidemiologic information are

going to be able to predict the severity prognosis of patients infected with COVID-19. we'll perform a multicenter retrospective longitudinal study to get an outsized variety of cases in a very short amount of your time, for higher study validation.

2) According to claim1# The Invention is to a Machine Learning Model for Predicting Severity Prognosis in Patients Infected with COVID-19.cis to the new coronavirus, that began to be known as SARS-CoV-2, could be a fiber polymer beta coronavirus, at first known in metropolis (Hubei province, China) and presently spreading across six continents inflicting a substantial hurt to patients, with no specific tools as yet to produce prognostic outcomes.
3) According to claim1,2# The Invention is to a gauge potential findings on chest CT of patients with signs and symptoms of metabolic process syndromes and positive epidemiologic factors for COVID-19 infection and to correlate them with the course of the sickness. during this sense, it's conjointly expected to develop specific machine learning formula for this purpose, through pneumonic segmentation, which may predict potential prognostic factors, through a lot of correct results.
4) According to claim1,2# The Invention is to a various hypothesis is that the machine learning model supported clinical, tomography and epidemiologic information are going to be able to predict the severity prognosis of patients infected with COVID-19. we'll perform a multicenter retrospective longitudinal study to get an outsized variety of cases in a very short amount of your time, for higher study validation.

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