Further Defining Gastric Emptying with Mathematical Models

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Introduction

- Solid-phase radionuclide gastric emptying scans (GES) are the gold standard for diagnosing gastroparesis (GP).
- Nonlinear mathematical modeling has previously been suggested to provide data on the lag times and the emptying components of gastric emptying.
- Clinically, thee first 10% of emptying time is often considered “lag time”.
- Calculation of best fit for lag time and emptying rates using mathematical modeling of GES data holds promise for accurate diagnosis of GP.
- The aim of this study was to compare non-linear modeling to the standard method of describing the lag and emptying components of GES.

Methods

- Deidentified data from Mayo Clinic for 20 GES performed in normal volunteers was analyzed using the Prism program (GraphPad Software, San Diego).
- Numeric data of the radioactive counts obtained from decay and depth corrected counts in sequential scans over 4 hours were converted to % remaining in the stomach.
- Four different best-fit models were used.
- The first analysis compared the following two phase nonlinear regressions:
  - Plateau followed by linear regression with the following formula:

    Y= IF (X< X0, Y0, Plateau+(Y0-Plateau) *Slope*X)
  - Plateau followed by one phase exponential decay with the following formula:

    Y= IF (X< X0, Y0, Plateau+(Y0-Plateau) *exp(-K*(X-X0)))
- In the second analysis, the lag time was assumed as 10% gastric emptying, and a linear regression was compared to an exponential decay for the remaining emptying portion of the GES.
- All models were then compared by goodness of fit by R^2, F test, and sum of squares.

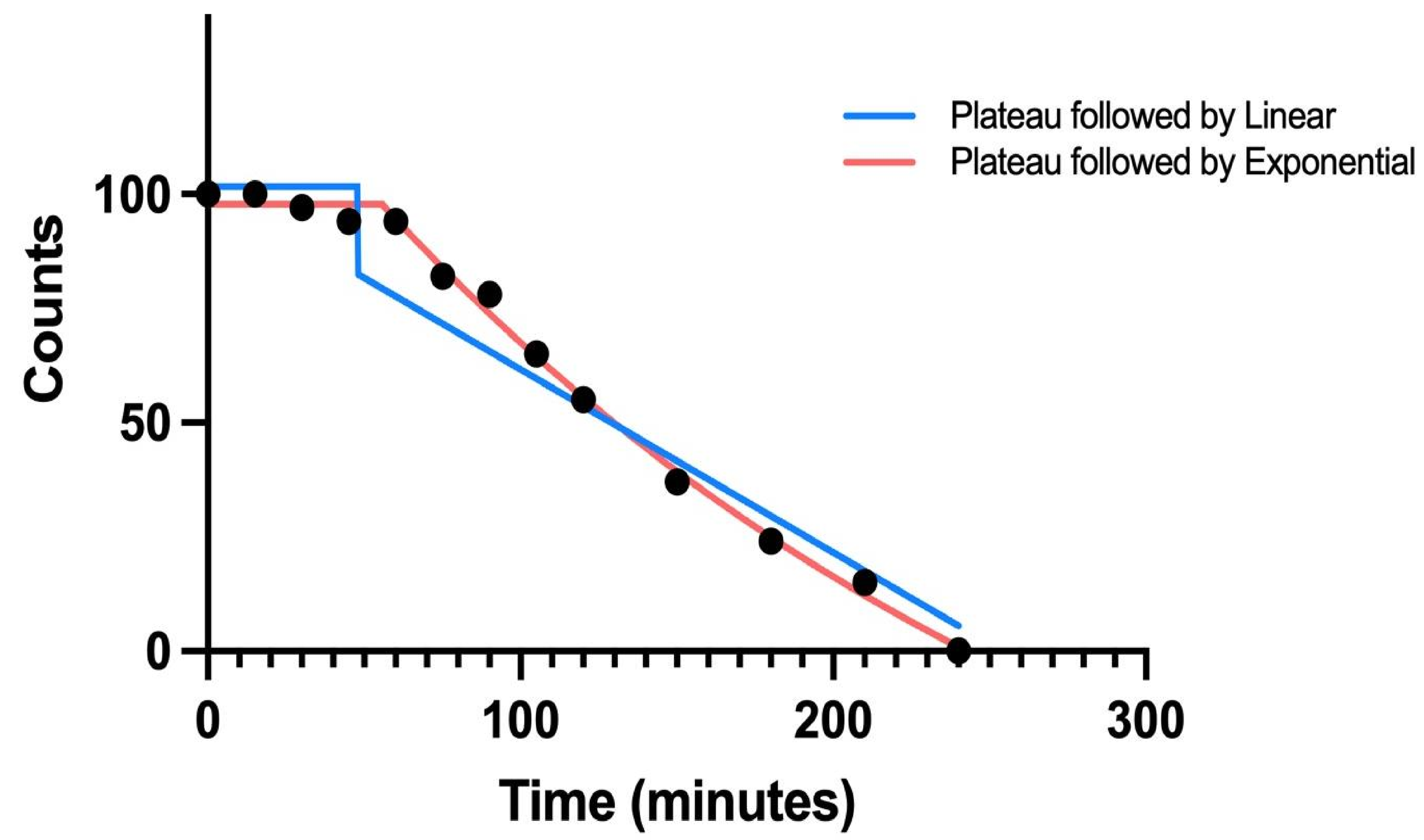

Figure 1: Graph comparing plateau followed by linear regression and plateau followed by exponential decay

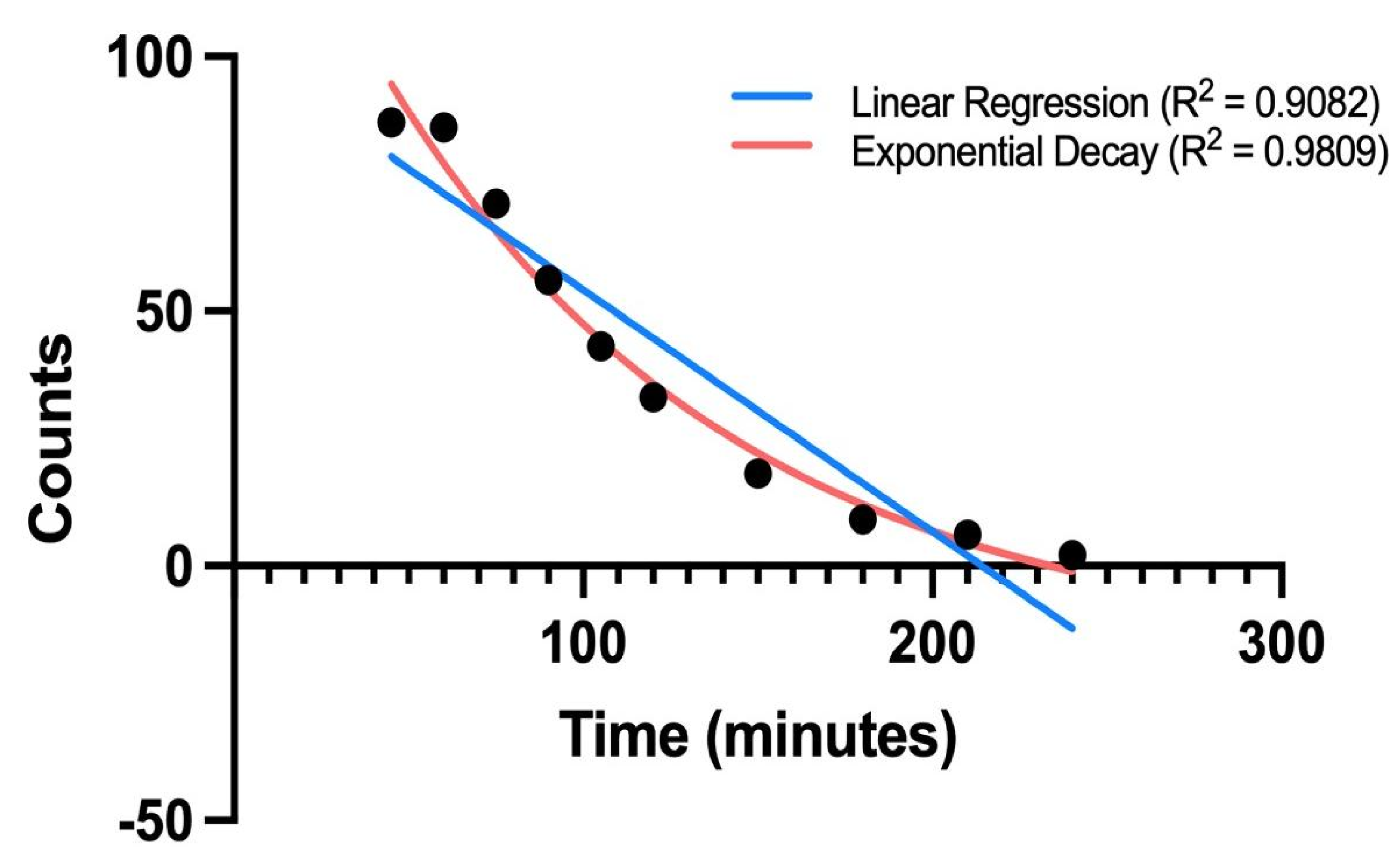

Figure 2: Graph with lag assumed as 10% emptying, comparing a linear regression model and exponential decay model.

Results

- For the two phase, non-linear regression models, the lag/linear decay model was not usable due to incalculable confidence intervals for lag time and slopes.
- Comparatively, the lag exponential model was usable in 8 cases (40%), (see Figure 1).
- When the data was forced through a lag time for 10% emptying, fitting of linear regression was possible in all cases, while exponential fitting was only possible in 10 cases.
- However, in 9 of the 10 cases, the R squared was higher for the exponential decay than the linear regression, (see Figure 2).

Disscussion/Conslusion

- In our analysis, non-linear modeling of GES could be performed in about 50% of cases.
- The current method of estimating lag time as 10% of emptying appears to be suitable in a clinical setting, but needs further exploration when used for research purposes.
- Characterization of the emptying phase of the GES is best performed by assessing whether this is a linear or exponential decay process in individual patients, especially in a research setting.
- This should result in a more accurate description of the GES.
- For example, a long lag time would suggest that there is either excessive gastric accomodation, or incomplete irutation. These patients could be managed with a small particle diet.
- Further exploration of these models in the clinical setting is suggested.

References

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