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Growth patterns of screen-detected malignant pulmonary nodules: Accuracy of doubling-time models

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Aims / Learning objectives

1. To determine volumetric growth patterns of lung cancer presenting as solid pulmonary nodules
2. To determine mass growth patterns of lung cancer presenting as subsolid pulmonary nodules
3. To determine the accuracy of exponential growth functions in modelling observed growth of early-stage lung cancer

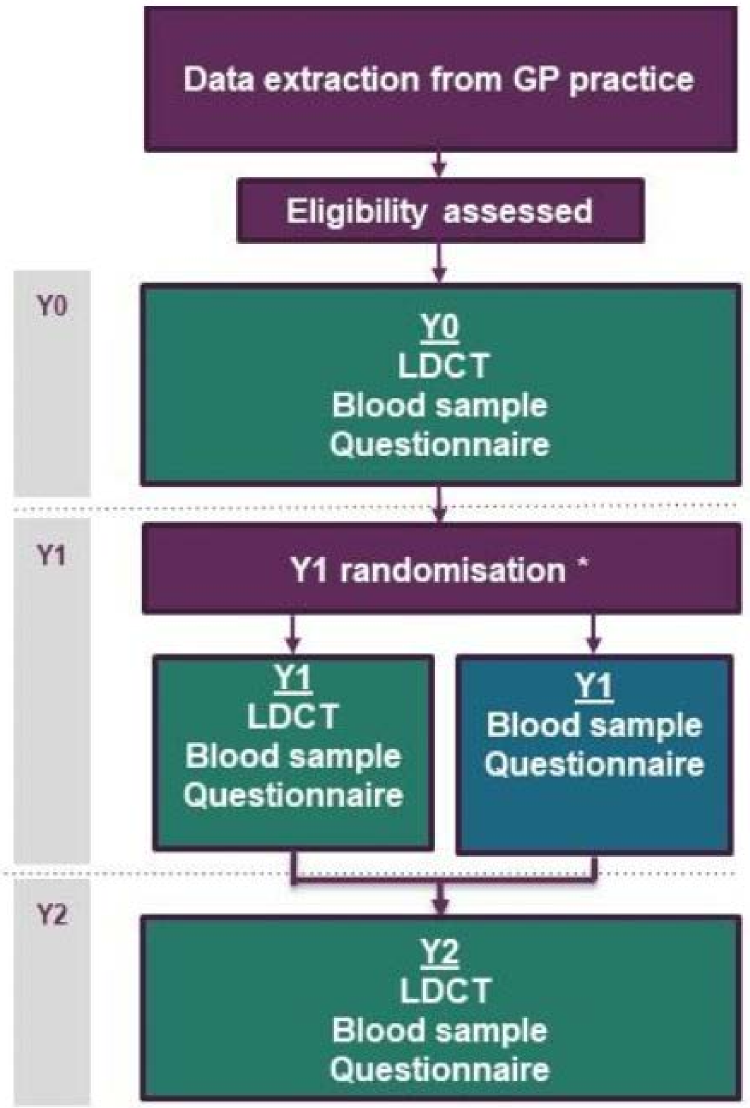
Background

- The use of volume-doubling time (VDT) to guide management decisions in indeterminate pulmonary nodules implies early-stage lung cancers follow a consistent exponential pattern of growth
- However, there is limited in vivo evidence for this
- Previous research in early lung cancer presenting as solid lung nodules has suggested exponential growth models closely fit observed growth[1]
- The aim of this analysis was to determine the accuracy of exponential functions in modelling observed growth of early-stage lung cancer presenting as solid (volume) and subsolid (mass) nodules in the SUMMIT study

[1]Quantification of growth patterns of screen-detected lung cancers: The NELSON study, MA Heuvelmans et al, Lung Cancer 2017

Methods: The SUMMIT study

- The SUMMIT study is a prospective observational cohort study to examine the performance of delivering a LDCT screening service to a high-risk population in London and to validate a multi-cancer early detection blood test (NCT03934866)
- Eligible participants were 55–77 years old, met the US Preventive Services Task Force 2013 screening criteria or had a $PLC0_{m2012}$ risk of ≥1.3%
- Participants attended three annual lung health checks
- Nodule management was based on British Thoracic Society guidelines[2]



Methods: Nodule analysis and modelling growth

- Images were read by thoracic radiologists using computer aided detection (CADe) software (Veolity V.1.4, MeVIS Medical Solutions)
- Individual nodules were tracked across serial study scans
- Predicted growth curves for each cancer were calculated by:

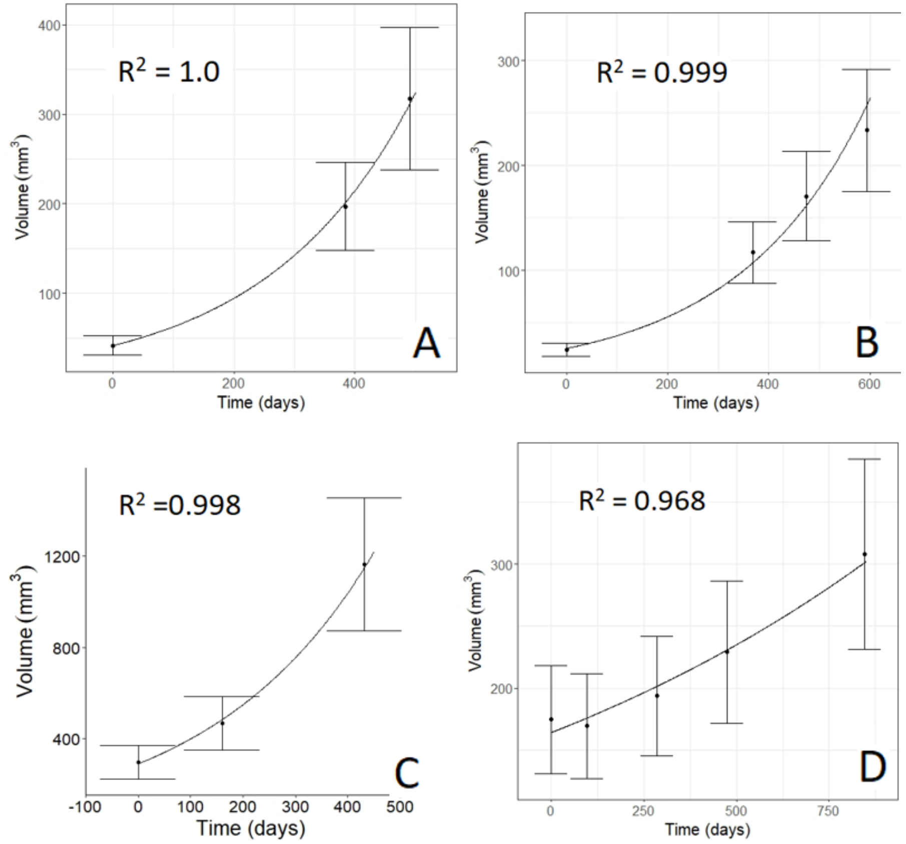
$$V_2 = V_0 \cdot 2^{(\Delta T/VDT)}$$
$$M_2 = M_0 \cdot 2^{(\Delta T/MDT)}$$

Where V_2 and V_0 and M_2 and M_0 were final and initial volume or mass respectively, VDT/MDT is volume/mass doubling time and ΔT is time.

- The accuracy of the predicted to observed growth was assessed with the Coefficient of Determination (R^2), where 1.0 is perfect fit

Results: Volume growth of solid nodules

- 21 histologically confirmed lung cancers diagnosed in solid nodules seen on 3 or more CTs were identified
- The observed growth fit an exponential growth model in the majority of cases with $R^2 \geq 0.90$ in 14/21 cancers
- Median R^2 0.9740 (IQR 0.849-0.9985)

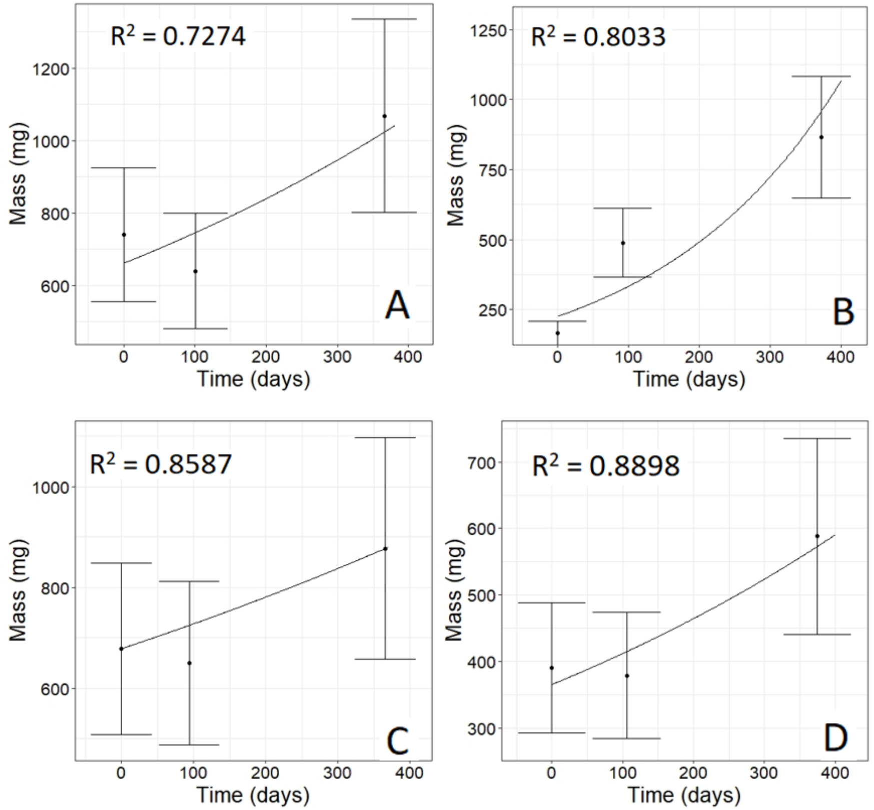


Example growth-patterns of screen-detected lung cancers derived from solid nodules

Points are measured volume and trend lines are modelled growth curves using an exponential growth function. Error margins are +/- 25% volume error. R^2 values are given for each nodule.

Results: Mass growth of subsolid nodules

- 21 histologically confirmed lung cancers derived from subsolid nodules seen on 3 or more SUMMIT scans were identified
- Mass growth of cancers presenting as subsolid nodules was less well predicted by an exponential model
- Mean R^2 0.687, median 0.8033 (IQR 0.4456-0.9080)(p=0.0054 *vs* volume growth of cancers presenting as solid nodules).
- 7/21 cancers had R^2 ≥0.9.



Example growth-patterns of screen-detected lung cancers derived from subsolid nodules

Points are measured mass and trend lines are modelled growth curves using an exponential growth function. Error margins are +/- 25% volume error. R^2 values are given for each nodule.

Conclusions

1. Volume growth of early-stage lung cancer presenting as solid nodules is well described by an exponential growth function
2. Mass growth of early-stage lung cancer presenting as subsolid nodules is less accurately modelled by an exponential growth function
3. These results support current guidelines that subsolid nodules require longer-term surveillance due to less predictable future growth

List of references

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