Better survival of patients with oligo- compared with polymetastatic cancers: a systematic review and meta-analysis of 173 studies [version 4; peer review: 2 approved]

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Abstract

Background: The modern concept of oligometastatic (OM) state has been initially developed to describe patients with a low burden of disease and with a potential for cure with local ablative treatments. We systematically assessed the risk of death and relapse of oligometastatic (OM) cancers compared to cancers with more diffuse metastatic spread, through a meta-analysis of published data.

Methods: PubMed, the Cochrane Library, and EMBASE were searched for studies reporting prognosis of patients with OM solid tumors. Risk of death and relapse were extracted and pooled to provide an adjusted hazard ratio with a 95% confidence interval (HR 95%CI). The primary outcome of the study refers to overall mortality in OM vs. polymetastatic (PM) patients.

Results. Mortality and relapse associated with OM state in patients with cancer were evaluated among 104,234 participants (n=173 studies). Progression-free survival was better in patients with OM disease (hazard ratio [HR] = 0.62, 95% CI 0.57–0.68; P <.001; n=69 studies). Also, OM cancers were associated with a better overall survival (OS) (HR = 0.65, 95% CI 0.62-0.68; P<.01; n=161 studies). In colorectal (CRC), breast, non-small cell lung cancer (NSCLC) and renal
cell carcinoma (RCC) the reduction in the risk of death for OM patients were 35, 38, 30 and 42%, respectively. Biliary tract and cervical cancer do not significantly better in OM stage likely for paucity of data. **Conclusions.** Patients with OM cancers have a significantly better prognosis than those with more widespread stage IV tumors. In OM cancer patients a personalized approach should be pursued.

**Keywords**
cancer, oligometastases, survival, review, meta-analysis, tumours

This article is included in the **Oncology** gateway.
Introduction
The vast majority of metastatic solid tumors are incurable, and despite the evolution of treatments, patients ultimately die because of their disease. The modern concept of oligometastatic (OM) state was initially developed in 1995 to describe patients with a low burden of disease (e.g. 1 to 3-5 metastases) with a potential for cure with local ablative treatments. This assumption also relies on the hypothesis that metastatic spread follows a hierarchical pattern in time and number of localizations. Large consensus on the definition and management of OM patients is currently lacking. Clinically, those cancers with a lower burden of metastatic disease have a favorable prognosis and they may be amenable of local treatment for the primary and distant tumors. Recently, in fact, advances in imaging and local ablative therapies have permitted the treatment of these patients with additional locoregional treatment in addition to systemic therapies, and some patients may be cured and attain long term survival. This scenario has been best elucidated in genitourinary, lung and melanomas. In these settings oligometastatic cancers may be treated in oligoprogressive sites continuing systemic therapy that control the remaining disease. One of the first published trials proving benefit of an aggressive local treatment of oligometastases was published in Lancet during 2019. In the SABR-COMET randomized study median overall survival (OS) was 28 months (95% CI 19-33) in the control group versus 41 months (26-not reached) in the stereotactic body radiotherapy to all metastases group (hazard ratio 0.57, 95% CI 0.30-1.10; P = .09).

The aim of this systematic review and meta-analysis was to investigate and establish the prognostic survival of OM compared to non-OM solid tumors. In particular, we evaluated if patients with oligometastatic solid tumors do better than patients with non-oligometastatic tumors.

Methods
This study followed the Preferred Reporting Items for Systematic Reviews and Meta-analyses (PRISMA) guidelines.

Search strategy and inclusion criteria
A comprehensive search was performed with the following terms: (advanced or metastatic or recurrent or relapsed or synchronous or metachronous) and (site or oligo* or “oligometastastic” or oligorecurrence or oligoprogression or single or multiple or 1-3 or >3 or >4 or >5 or 1-2 or 1-3 or 1-5 or number) and (synchronous or metachronous or metastases or relapse or recurrence or progression) and (tumor or tumour or cancer or carcinoma or melanoma or sarcoma) and (“hazard ratio”) and (cox or multivariate or multivariable) and survival. We searched PubMed, the Cochrane Library and EMBASE for studies eligible for this meta-analysis published in English language from inception up to October 30th, 2020. To be eligible, studies needed to have evaluated survival of patients with OM cancers (1 up to 3/5 metastases regardless of anatomic sites) regardless of line of therapy and to provide data of outcome according to the number of OM sites used by each author. Studies were excluded if they enrolled less than 10 patients, pediatric subjects, and hematological diseases. Commonly we define polymetastatic cancer as any disease with more than three or more than five metastases. Studies were searched and screened independently by three authors (FP, MG and GT).

Quality of studies and endpoints
The primary endpoint was overall survival (OS) and the secondary endpoint was progression-free survival (PFS). Quality assessment of the included studies was performed using the Newcastle-Ottawa Scale (NOS) for observational or retrospective studies (http://www.ohri.ca/programs/clinical_epidemiology/oxford.asp). With NOS scale, studies were defined as poor, sufficient or good quality if scores (the sum of points attributed to each domain) were <6, 6 or 7-9 points, respectively.

Data extraction and statistical analysis
The extracted data (from six reviewers) included the type of study, number of patients, cancer type, median age of included patients, performance status 0-1 (rate), treatment received, timing of oligometastases (synchronous or
metachronous), number of OM sites used for comparison, and median follow up. Hazard ratios (HR) for OS and PFS with their 95% CIs, were extracted preferentially from multivariate analyses where available. The heterogeneity in the included studies was evaluated by the Chi-square-based Q-test and $I^2$ ($I^2 = 0\%$ to 25\%, no heterogeneity; $I^2 = 25\%$ to 50\%, moderate heterogeneity; $I^2 = 50\%$ to 75\%, high heterogeneity; $I^2 = 75\%$ to 100\%, extreme heterogeneity). When $I^2$ was larger than 50\%, a random effects model was used; otherwise, the fixed effects model was used. Sensitivity analyses for OS were performed according to type of cancer, timing and number of oligometastases to find the potential heterogeneity among the included studies. If the number of studies was less than or equal to one, we did not carry out the subgroup analysis. The possibility of publication bias was explored by the Egger’s and Begg’s tests and Trim and Fill method.$^7$ Begg’s test explores bias with a funnel plot, conversely Egger’s test is a linear regression of the effect estimates (OS) on their standard errors weighted by their inverse variance. The trim-and-fill method aims at estimating potentially missing studies due to publication bias in the funnel plot and adjusting the overall effect estimate. All analyses were performed using RevMan v.3 software.$^9$

**Results**

Among the publications retrieved using electronic search ($n = 7510$), 173 studies were eligible for meta-analysis, for a total of 104,234 patients$^{10}$ (Figure 1). Baseline characteristics of the included studies and treatments received are presented in Table 1.
## Table 1. Characteristics of included studies.

| Author/year | N pts | Disease | Median age (years) | PS | Type of study | Median follow-up (months) | Definition of OM | Site of OM | De novo / metachronous (%) | Treatment for OM (%) | OS | PFS | Quality |
|-------------|-------|---------|-------------------|----|---------------|---------------------------|-----------------|-----------|---------------------------|----------------------|-----|------|---------|
| Morino/2020 | 232   | Biliary | 66                | NR | Retrospective | 12.6                      | Various         | Locoregional/ Systemic | CT (100) var | MVA | MVA | 5     |
| Park/2017   | 134   | Biliary | 61                | 90 | Retrospective | 26                        | Various         | Various                | CT (100) var | MVA | MVA | 5     |
| Luzardo/2019| 1592  | Bladder | NR                | NR | Retrospective | 1.44                      | Various         | Various                | CT (100) var | MVA | MVA | 5     |
| Bates/2011  | 96    | Breast  | NR                | NR | Retrospective | 34                        | Various         | Various                | CT (100) var | MVA | MVA | 5     |
| Blachet/2018| 154   | Breast  | NR                | 55 | Retrospective | 1.5                       | Various         | Various                | CT (100) var | MVA | MVA | 5     |
| Lu/2017     | 134   | Breast  | NR                | 62 | Retrospective | 25.75                     | Various         | Various                | CT (100) var | MVA | MVA | 5     |
| Luzzago/2019| 1592  | Bladder | NR                | NR | Retrospective | NR                        | Various         | CT (100) var | MVA | MVA | 5     |
| Bates/2011  | 96    | Breast  | NR                | NR | Retrospective | NR                        | Various         | CT (100) var | MVA | MVA | 5     |
| Lipton/2010 | 102   | Breast  | NR                | 55 | Retrospective | 1.5                       | Various         | Various                | CT (100) var | MVA | MVA | 5     |
| Lobbezoo/2015| 815  | Breast  | NR                | 62 | Retrospective | 1.17                      | Various         | Various                | CT (100) var | MVA | MVA | 5     |
| Le Scodan/2009| 581  | Breast  | NR                | 61 | Retrospective | 3                        | Various         | Various                | CT (100) var | MVA | MVA | 5     |
| Kikawa/2019 | 134   | Breast  | NR                | 63 | Retrospective | 1.41                      | Various         | Various                | CT (100) var | MVA | MVA | 5     |
| Gu/2020     | 16702 | Breast  | NR                | 61 | Retrospective | 48.5                      | Various         | Various                | CT (100) var | MVA | MVA | 5     |
| Neuman/2010 | 186   | Breast  | NR                | 56 | Retrospective | 52                        | Various         | Various                | CT (100) var | MVA | MVA | 5     |
| Nguyen/2012 | 692   | Breast  | NR                | 60 | Retrospective | 22.8                      | Various         | Various                | CT (100) var | MVA | MVA | 5     |
| Nichul/2012 | 314   | Breast  | NR                | 48 | Retrospective | 43.9                      | Various         | Various                | CT (100) var | MVA | MVA | 5     |
| Ran/2020    | 49    | Breast  | NR                | 50 | Retrospective | 29                        | Various         | Various                | CT (100) var | MVA | MVA | 5     |
| Author/year   | N pts | Disease | N° of pts | Median age (years) | Type of study | Median follow up (months) | Definition of OM (n° of lesions)/% | Site of OM | De novo / metachronous (% | Treatment for OM (%) | PsS: UVA or MVA | PFS: UVA or MVA | OS: UVA or MVA | Quality |
|--------------|-------|---------|-----------|-------------------|---------------|---------------------------|-----------------------------------|-----------|--------------------------|---------------------|----------------|----------------|----------------|---------|
| Phu/2014     | 262   | Breast  | 47        | N R               | Retrospective | 20.6                      | 1-2 (84.7)                        | Various | -                        | N R                 | MVA            | -              | -              | 6       |
| Schneeweiss/2002 | 118  | Breast  | 48        | N R               | Retrospective | 48                        | 1-2 (86)                          | Various | -                        | N R                 | UVA            | -              | -              | 7       |
| Wang/2019    | 483   | Breast  | 49        | N R               | Retrospective | 66                        | 1-8 (88)                          | Various | -                        | N R                 | UVA            | -              | -              | 7       |
| Smart/2019   | 66    | BTC     | 76        | N R               | Retrospective | 21                        | 1-2 (54)                          | Various | -                        | N R                 | UVA            | -              | -              | 7       |
| Yin/2019     | 99    | Cervix  | 93        | N R               | Retrospective | 11.6                      | 1.3 (37.3)                        | Various | -                        | N R                 | MVA            | -              | -              | 6       |
| Afshari/2019 | 251   | CRC     | 62        | N R               | Retrospective | 52.7                      | 1-4 (75.7)                        | Liver    | 63.97                    | Various | MVA | -              | -              | 8       |
| Ankori/2017  | 342   | CRC     | 80        | N R               | Retrospective | 100                       | Phase 3                           | Liver    | 69.8                     | Various | MVA | -              | -              | 8       |
| Aparicio/2015| 318   | CRC     | 58        | N R               | Retrospective | 60                        | 1-4 (43)                          | Various | 28.7                     | Liver    | S + CT (100) | MVA | -              | -              | 6       |
| Bache/2019   | 249   | CRC     | 62.9      | N R               | Retrospective | 44.5                      | 1.3 (66)                          | Liver    | 79/21                    | Liver    | MVA | -              | -              | 7       |
| Baldin/2021  | 221   | CRC     | 62        | N R               | Retrospective | 62                        | 1-5 (NR)                          | Liver    | 74/25.8                  | Liver    | MVA | -              | -              | 5       |
| Beppi/2014   | 137   | CRC     | 63        | N R               | Retrospective | 57                        | 1-2 (32)                          | Liver    | 51/49                    | Liver    | MVA | -              | -              | 6       |
| Blazer III/2008 | 305  | CRC     | 57        | N R               | Retrospective | 45                        | 1-8 (61)                          | Various | 33                       | Liver    | MVA | -              | -              | 6       |
| Brand/2013   | 151   | CRC     | 61.5      | N R               | Retrospective | 100                       | Retrospective                     | Liver    | 51/49                    | Liver    | MVA | -              | -              | 5       |
| Creasy/2018  | 907   | CRC     | 64        | N R               | Retrospective | 69.5                      | 1-2 (90)                          | Liver    | 0/100                    | Various | MVA | -              | -              | 6       |
| Cristoval/2014| 250  | CRC     | 67        | N R               | Retrospective | 92                        | 1-4 (64)                          | Various | 11.9                     | Liver    | MVA | -              | -              | 6       |
| Cornella/2005| 254   | CRC     | 97        | N R               | Retrospective | 45                        | N R                               | Liver    | 54/46                    | Various | MVA | -              | -              | 5       |
| Crompton/2013| 1004  | CRC     | 67        | N R               | Retrospective | 100                       | Retrospective                     | Liver    | 1000                    | Various | MVA | -              | -              | 5       |
| Carbon/2013  | 255   | CRC     | 67        | N R               | Retrospective | 92                        | 1-3 (64)                          | Various | 11.9                     | Liver    | MVA | -              | -              | 6       |
| Dharm/2010   | 152   | CRC     | 61.5      | N R               | Retrospective | 83                        | 1-2 (85)                          | Liver    | 15/42                    | Liver    | MVA | -              | -              | 6       |
| Duflo/2006   | 152   | CRC     | 62        | N R               | Retrospective | 62                        | 1-2 (33)                          | Liver    | 54/46                    | Liver    | MVA | -              | -              | 6       |
| Elfar/2008   | 742   | CRC     | 63        | N R               | Retrospective | 63                        | 1-4 (140)                         | Liver    | 15/42                    | Liver    | MVA | -              | -              | 6       |
| Fonan/2015   | 810   | CRC     | 65        | N R               | Retrospective | 59                        | 1-2 (85)                          | Liver    | 15/42                    | Liver    | MVA | -              | -              | 6       |
| Gheni/2014   | 209   | CRC     | 65        | N R               | Retrospective | 59                        | 1-2 (85)                          | Liver    | 15/42                    | Liver    | MVA | -              | -              | 6       |

Table 1. Continued
Table 1. Continued

| Author/year  | N pts | Disease | Median age (years) | PS 0-1 (%) | Type of study | Median follow up (months) | Definition of OM (n° of lesions)/% | Site of OM | De novo / metachronous (%) | Treatment for OM (%) | OS (UVA or MVA) | PFS (UVA or MVA) | Quality |
|--------------|-------|---------|-------------------|------------|---------------|--------------------------|----------------------------------|------------|--------------------------|---------------------|----------------|----------------|---------|
| Gu/2018      | 102   | CRC     | 62                | NR         | Retrospective | NR                       | 1 (36)                           | Liver      | 0/100                    | RFA ± CT (100)       | MVA            | -              | 5       |
| Hebbar/2015  | 284   | CRC     | 61.7              | 93         | Phase 3       | 67                       | 1 (48.9)                         | Various / Liver R3.5               | 67.7/32.3    | S ± CT (100)               | -                   | MVA (DFS)      | 8       |
| Hernandez/2016 | 522 | CRC     | 64.5              | NR         | Retrospective | 38.7                     | 1 (65.7)                         | Lung       | -                        | CT                  | MVA            | MVA           | 6       |
| Holliday/2017 | 34   | CRC     | 56                | NR         | Retrospective | 25                       | 1-2 (100)                        | Various    | 100/0                    | SCRT               | MVA            | MVA           | 6       |
| Huang/2020   | 179   | CRC     | 62                | NR         | Retrospective | 27.6                     | 1 (51.5)                         | Lung       | -                        | S (100)             | MVA            | -              | 6       |
| Ishiguro/2006 | 111  | CRC     | NR                | NR         | Retrospective | 43                       | 1-3 (81)                          | Liver      | 100/0                    | S (100)             | MVA            | -              | 9       |
| Kemeny/2014  | 169   | CRC     | 55                | NR         | Retrospective | 44.3                     | 1-2 (47.3)                       | Various    | 66.8/33.2                | S + HAI + Systemic tx (100) | -              | MVA (DFS)     | 7       |
| Konopke/2009 | 201   | CRC     | 65                | NR         | Prospective   | 31                       | 1-3 (94)                          | Liver      | 34.8/65.2                | S (100)             | MVA            | MVA           | 6       |
| Leal/2016    | 513   | CRC     | 64.1              | NR         | Retrospective | 37                       | 1 (61.6)                          | Liver      | 100/0                    | S                  | MVA            | MVA (DFS)     | 6       |
| Lin/2018     | 307   | CRC     | 57.5              | NR         | Retrospective | 31.7                     | 1 (52.8)                          | Liver      | 66.4/33.6                | S (100) ± RFA (10.1) ± Systemic tx | MVA            | -              | 7       |
| Liu/2010     | 52    | CRC     | 70                | NR         | Retrospective | 35.5                     | 1 (58)                            | Liver      | 0/100                    | S ± CT (100)         | MVA (DFS)       | MVA           | 6       |
| Liu/2020     | 182   | CRC     | 59.5              | NR         | Retrospective | 32.5                     | 1-3 (NR)                          | Liver      | 65/35                    | S ± CT              | MVA (DFS)       | MVA           | 6       |
| Margonis/2015| 334  | CRC     | 50                | NR         | Retrospective | 28.2                     | 1-2 (NR)                          | Liver      | 54.8/45.2                | S (100)             | UVA            | MVA (DFS)     | 6       |
| Margonis/2017| 389  | CRC     | 58.4              | NR         | Retrospective | 20.8                     | 1-2 (NR)                          | Liver      | 57.3/42.7                | S ± Ablation (18.5) ± CT (71.5) | -              | MVA (DFS)     | 6       |
| Margonis/2019| 718  | CRC     | 62.3              | NR         | Retrospective | 30.4                     | 1-3 (36.4)                        | Liver      | 51.2/48.8                | S ± Systemic tx     | MVA            | -              | 6       |
| Mise/2010    | 98    | CRC     | 62                | NR         | Retrospective | 60                       | 1-3 (68)                          | Various    | 0/100                    | S (100)             | MVA            | -              | 8       |
| Miyamoto/2015| 78   | CRC     | 65                | 92         | Retrospective | 19.2                     | 2 (37)                            | Various    | -                        | -                  | UVA            | -              | 6       |
| Narayan/2020 | 357  | CRC     | 60                | NR         | Prospective   | 127                      | 1 (NR)                            | Liver      | 100/0                    | S ± HAI             | -              | UVA (DFS)     | 9       |
| Negri/2005   | 135   | CRC     | 60.5              | 82.2       | Case–control  | 76.8                     | 1 (60.7)                          | Various    | 100/0                    | CT (100)            | MVA            | -              | 8       |
| Neofytou/2015| 140  | CRC     | NR                | NR         | Retrospective | 33                       | 1 (41.4)                          | Liver      | 71.4/28.6                | ± S ± Systemic tx   | UVA            | UVA           | 6       |
| Nojiri/2011  | 31    | CRC     | 63.3              | NR         | Retrospective | 62                       | 1-2 (64.5)                        | Lung       | 3.2/96.8                 | S (100)             | MVA            | -              | 8       |
| Park/2016    | 221   | CRC     | 62                | NR         | Prospective   | 34.7                     | 1 (73.3)                          | Lung       | 13.1/86.9                | S (100) ± CT (79.6) | UVA            | MVA (DFS)     | 6       |
| Author/year | N pts | Disease | Median age (years) | Type of study | Median follow-up (months) | Definition of OM | Site of OM (%) | De novo / metachronous (n° of lesions)/% | Treatment for OM (%) | OS (UVA or MVA) | PFS (UVA or MVA) |
|-------------|-------|---------|-------------------|---------------|--------------------------|-----------------|------------|---------------------------------------|-----------------------|----------------|----------------|
| Parkin/2013  | 5853  | CRC     | 64                | Retrospective  | 20                       | 1-3 (79)        | Liver      | 37/50                                 | Surgery (100)         | MVA - 5          | MVA - 6        |
| Peng/2017    | 150   | CRC     | NR                | Retrospective  | 36                       | 1 (NR)         | Liver      | 67/33                                 | MVA (100)             | MVA - 6        | MVA - 6        |
| Peng/2018    | 140   | CRC     | 55                | Retrospective  | 13                       | 1-3 (79)        | Liver      | 70/30                                 | MVA (100)             | MVA - 5        | MVA - 6        |
| Prosanna/2020| 513   | CRC     | 63                | Retrospective  | 34                       | 1 (63)         | Liver      | 51/49                                 | CT (100)              | MVA - 6        | MVA - 6        |
| Rhisalim/2012| 410   | CRC     | 60                | Retrospective  | NR                       | 1-3 (65)        | Liver      | 0/100                                 | CT (100)              | UVA - 5        | UVA - 5        |
| Rizzo/2012   | 485   | CRC     | 59                | Retrospective  | NR                       | 1-3 (65)        | Liver      | 57/43                                 | CT (100)              | UVA - 5        | UVA - 5        |
| Santarelli/2017| 351  | CRC     | 57               | Retrospective  | 30.3                      | 1.3 (NR)       | Liver      | 18/83                                 | MVA - 6              | UVA - 5        | UVA - 5        |
| Sasaki/2016  | 160   | CRC     | NR                | Retrospective  | 64                       | 1-3 (88)        | Liver      | 34/56/45                              | MVA - 6              | MVA - 5        | MVA - 6        |
| Shen/2015    | 342   | CRC     | NR                | Subgroup analysis of prospective randomised controlled trial | 98.8          | 1 (53)      | Liver      | 1-2 (53)                              | MVA (100)             | MVA - 6        | MVA - 6        |
| Stang/2016   | 168   | CRC     | NR                | Retrospective  | 99                       | 1-3 (77)        | Liver      | 21/79                                 | MVA - 6              | MVA - 5        | MVA - 6        |
| Streitberg/2015| 113  | CRC     | 70                | Retrospective  | 34                       | 1-2 (NR)       | Liver      | 1.2 (NR)                              | MVA (100)             | MVA - 5        | MVA - 6        |
| Tanigawa/2014| 154   | CRC     | 62                | Retrospective  | 37                       | 0.1 (29)       | Liver      | 37/62/44                              | MVA (100)             | MVA - 5        | MVA - 6        |
| Van Cutsem/2004| 1207 | CRC     | 64                | Retrospective  | 37                       | 1.3 (25)       | Liver      | 27/62/44                              | MVA (100)             | MVA - 5        | MVA - 6        |
| Wang/2017    | 163   | CRC     | 65                | Retrospective  | 37                       | 1.2 (41)       | Liver      | 8/218                                 | MVA (100)             | MVA - 5        | MVA - 6        |
| Wei/2005     | 395   | CRC     | 63                | Retrospective  | 31                       | 1.3 (65)       | Liver      | 51/49                                 | MVA (100)             | MVA - 6        | MVA - 6        |
| Xiong/2018   | 332   | CRC     | 59                | Retrospective  | NR                       | 27.7 (65.2)    | Liver      | 7/18/44                               | MVA - 6              | MVA - 6        | MVA - 6        |
| Yanagita/2017| 74    | CRC     | NR                | Retrospective  | NR                       | 1.7 (74)       | Liver      | 66/34                                 | MVA (100)             | MVA - 5        | MVA - 6        |
| Zhao/2017    | 289   | CRC     | NR                | Retrospective  | NR                       | 1.5 (151)      | Liver      | 66/34                                 | MVA (100)             | MVA - 5        | MVA - 6        |
| Alizai/2017  | 345   | CRC     | 66                | Retrospective  | NR                       | 1.3 (NR)       | Liver      | 66/34                                 | MVA (100)             | MVA - 5        | MVA - 6        |
| Hashimura/2010| 466   | CRC     | 85                | Retrospective  | NR                       | 1.2 (NR)       | Liver      | 66/34                                 | MVA (100)             | MVA - 5        | MVA - 6        |
| Kandziora/2013| 208  | CRC     | NR                | Retrospective  | NR                       | 1.1 (67.9)     | Liver      | 26.9/72.6                              | CT (100)              | MVA - 5        | MVA - 6        |
| Kimmann/2008| 304   | CRC     | 64                | Retrospective  | NR                       | 1.8 (12)       | Liver      | 44/56                                 | MVA (100)             | MVA - 5        | MVA - 6        |
| Krzyzewski/2019| 103  | CRC     | 67                | Retrospective  | NR                       | 1.2 (89)       | Liver      | 2.2/89                                | MVA (100)             | MVA - 5        | MVA - 6        |
| Author/year | N pts | Disease | Median age (years) | PS 0-1 (%) | Type of study | Median follow up (months) | Definition of OM (n° of lesions)/% | Site of OM | De novo / metachronous (%) | Treatment for OM (%) | OS (UVA or MVA) | PFS (UVA or MVA) | Quality |
|-------------|-------|---------|-------------------|-----------|--------------|--------------------------|-----------------------------------|------------|---------------------------|---------------------|---------------|-----------------|---------|
| Kinoshita/2015 | 256 | Gastric | 64 | NR | Retrospective | 65 | 1-2 (82.8) | Liver | 41.4/58.6 | S (100) + CT (32.8) | MVA | UVA | 8 |
| Kondoh/2018 | 50 | Gastric | 67 | 72 | Retrospective | NR | 1-2 (74) | Various | - | CT (100) | UVA | - | 5 |
| Makiyama/2018 | 444 | Gastric | 75 | NR | Retrospective | 28.7 | 1 (37.3) | Various | - | CT (100) | - | MVA | 5 |
| Wang/2016 | 310 | Gastric | 58 | 100 | Retrospective | NR | 1 (70.6) | Various | - | Various | MVA | - | 5 |
| Wang/2018 | 321 | Gastric | 57 | 85 | Retrospective | NR | 0-1 (83) | Various | - | CT (100) | MVA | MVA | 6 |
| Liu/2015 | 981 | HCC | 52.5 | NR | Prospective | 32.7 | 1 (70.3) | Liver | - | ± S (18.9) ± RFA (19.3) ± TACE (48.2) | - | MVA (RTDS) | 7 |
| Mazzaferro/2009 | 1556 | HCC | 55 | NR | Retrospective | 53 | 1 (26) | Liver | - | S (100) | MVA | - | 7 |
| Yoon/2010 | 52 | HCC | 49 | Retrospective | 16.3 | 1 (75) | Lung | - | S (100) | MVA | - | 6 |
| Bollig/2020 | 283 | Head & neck | 59.8 | NR | Retrospective | NR | 1 (18.7) | Various | - | Various (100) | MVA | - | 5 |
| Lo/2017 | 120 | Head & neck | NR | NR | Retrospective | NR | 1-3 (68.3) | LNs | - | S ± CT/RT | MVA (D5S) | - | 8 |
| Shen L/2015 | 505 | Head & neck | NR | 95 | Retrospective | 20 | 1 (18.8) | Various | 100/0 | CT ± RT (100) | MVA | - | 6 |
| Shen L/2015 (2) | 312 | Head & neck | 46 | 89.1 | Retrospective | 16 | 1-3 (62.2) | Bone | 43.9/56.1 | Various | MVA | - | 6 |
| Shinoda/2020 | 48 | Liposarcoma | 43 | NR | Retrospective | 27.5 | 1 (52.1) | Various | - | Various | UVA (DSS) | - | 5 |
| Li/2019 | 100 | Lung | 60 | 96.1 | Retrospective | 39 | 1-3 (13.7) | Brain | 100/0 | TKI ± CT | UVA | - | 7 |
| Prelaj/2019 | 193 | Lung | 65 | 88 | Retrospective | 43 | 1-3 (NR) | Various | - | IT (100) | UVA | MVA | 7 |
| Bian/2016 | 401 | Melanoma | NR | 83 | Retrospective | 35 | 1-4 (87) | CNS | - | SBRT (100) | MVA | - | 7 |
| Jacomo/2019 | 162 | Melanoma | NR | 82 | Retrospective | 48 | 1-2 (66) | Various | - | Systemic tx (100) | MVA | - | 7 |
| Lee/2009 | 2247 | Melanoma | 51 | NR | Retrospective | 22.5 | 1-2 (67.4) | Various | - | - | MVA | - | 6 |
| Moreau/2012 | 115 | Melanoma | 59 | NR | Retrospective | 19 | 1-3 (64) | LNs | 93/7 | S (100) | MVA | MVA (DMFS) | 6 |
| Seremet/2019 | 85 | Melanoma | 57 | 91 | Retrospective | 21 | 1-2 (44.7) | Various | - | ICIs (100) | MVA | UVA | 6 |
| Weide/2012 | 855 | Melanoma | 62 | NR | Retrospective | 25 | 1-2 (74.7) | Various | - | Various | MVA | - | 6 |
| Robelin/2019 | 162 | Neuroendocrine | 61 | 90 | Retrospective | 56 | 1-2 (85) | Various | 49/51 | Various | MVA | UVA | 7 |
| Jiang/2015 | 347 | NPC | 48 | 100 | Retrospective | NR | 1 (28) | Various | 100/0 | CT (57.9) | MVA | - | 5 |
| Nie/2017 | 209 | NPC | 45 | 81.3 | Retrospective | 16.6 | 1 (49.8) | Various | 24.9/75.1 | CT (100) | UVA | UVA | 6 |
| Beau-Faller/2019 | 228 | NSCLC | NR | 42 | Retrospective | NR | 1-2 (65) | Various | 0/100 | TKI (100) | MVA | MVA | 5 |
| Author/year | N° pts | Disease | Median age (years) | PS 0-1 (%) | Type of study | Median follow up (months) | Definition of OM (n° of lesions)/% | Site of OM | De novo / metachronous (%) | Treatment for OM (%) | OS (UVA or MVA) | PFS (UVA or MVA) | Quality |
|-------------|--------|---------|-------------------|------------|---------------|-------------------------|------------------------------------|-----------|---------------------------|-------------------|----------------|----------------|---------|
| Ding/2017   | 85     | NSCLC   | 66                | 75         | Retrospective | 9.8                    | 1-3 (48)                           | Various   | -                         | TKI (94)          | MVA            | MVA           | 6       |
| Liu/2018    | 216    | NSCLC   | 57                | NR         | Retrospective | 7                      | 1-3 (NR)                           | Brain     | -                         | RT ± Systemic tx | MVA            | -             | 6       |
| Niibe/2016  | 61     | NSCLC   | NR                | 100        | Retrospective | 7.3                    | 1-2 (89)                           | SNC       | 18/82                     | SBRt or SRS (100) | MVA            | -             | 5       |
| Paccagnella/2006 | 324 | NSCLC   | 62                | 93.7       | Phase 2-3    | 19                     | 1 (30.5)                           | Various   | 100/0                     | CT (100)          | UVA            | UVA           | 6       |
| Park/2019   | 517    | NSCLC   | 64                | NR         | Retrospective | 6.0                    | 1 (57)*                            | Various   | 100/0                     | Various           | MVA            | -             | 5       |
| Shin/2016   | 1024   | NSCLC   | 64                | 85.5       | Retrospective | 42.2                   | 1 (14.8)*                          | Various   | -                         | Systemic tx (100) | MVA            | -             | 7       |
| Sperduto/2016 | 1481 | NSCLC   | NR                | 69.2       | Retrospective | 1-4 (81)               | Brain                              | -         | Various                   | MVA              | -             | 5             | 6       |
| Takahashi/2019 | 41  | NSCLC   | 67                | 82         | Retrospective | 19.6                   | 1 (57)                             | Bone      | 100/0                     | Various (100)     | UVA            | UVA           | 6       |
| Tambo/2020  | 95     | NSCLC   | 72                | 77.9       | Retrospective | 8.8                    | 1-2 (80)                           | NR        | -                         | Pembrolizumab (100) | MVA            | -             | 5       |
| Liu/2020    | 125    | Osteosarcoma | 17        | 100        | Retrospective | NR                    | 1-2 (72)                           | Lung      | -                         | CT ± S            | - MVA (PRS)    | -             | 5       |
| Bolm/2015   | 39     | Pancreatic | NR              | 56         | Retrospective | 5                      | 1 (56)                             | Various   | -                         | RT (100)          | MVA            | -             | 6       |
| Neron/2020  | 51     | Phyllodes | 56.4             | 95.9       | Retrospective | 62.1                   | 1 (51)                             | Various   | 13.7/86.3                 | ± S (31.3) ± RT (31.9) ± CT (72.5) | UVA            | -             | 7       |
| Armstrong/2007 | 686 | Prostate | 68.5             | 88         | Retrospective | 70                    | 1-2 (88)                           | Various   | -                         | CT (100)          | MVA            | -             | 9       |
| Tablazon/2019 | 837 | Prostate | 76                | NR         | Retrospective | 26                    | 1 (NR)                             | Bone      | -                         | -                | MVA            | -             | 7       |
| Zhang/2020  | 160    | Prostate | 68                | NR         | Retrospective | 47.2                   | 1-4 (39.4)                         | Bone      | -                         | RT + OT (100)     | UVA            | -             | 7       |
| Alt/2011    | 887    | RCC      | 62.5              | 85         | Retrospective | 33.6                   | 2 (16.5)                           | Various   | 58/42                     | S (14)            | MVA            | -             | 8       |
| Atzpoldien/2003 | 425 | RCC      | NR                | 100        | Retrospective | 20                    | 1-2 (82)                           | Various   | 0/100                     | Various           | MVA            | -             | 7       |
| Beuselink/2014 | 200 | RCC      | 59                | 85         | Retrospective | 67                    | 1 (83)                             | Various   | 38/62                     | Systemic tx (100) | UVA            | UVA           | 8       |
| Bossé/2020  | 3454   | RCC      | 62                | 61         | Retrospective | 34.2                 | 1 (19.5)                            | NR        | -                         | TKI (100)          | MVA            | -             | 6       |
| Cai/2017    | 143    | RCC      | 60                | NR         | Retrospective | 22                    | 1 (72.7)                           | Various   | -                         | TKI (100)          | UVA            | UVA           | 6       |
| Dai/2020    | 146    | RCC      | 56.5              | 71.9       | Retrospective | 36                    | 1 (56.8)                           | Various   | 45.9/54.1                 | TKI (100)          | MVA            | MVA           | 6       |
| Fay/2018    | 4736   | RCC      | 59.2              | 100        | Pooled analysis of n=12 phase 2-3 trials | NR | 1 (NR) | - | - | - | MVA | - | 6 |
| Fujiwara/2020 | 45   | RCC      | 62                | 82         | Retrospective | 26.4                   | 1 (36)                             | NR        | -                         | Nivolumab (100)   | UVA            | -             | 6       |
| Furubayashi/2017 | 59  | RCC      | 67                | 85         | Retrospective | 1-2 (86)               | Various   | -                         | TKI (100)          | MVA            | -             | 5       |
| Gu/2017     | 184    | RCC      | 54                | NR         | Retrospective | 23.3                   | 1 (85)                             | Various   | -                         | Various           | UVA            | MVA           | 6       |
| Ikeda/2018  | 116    | RCC      | 66                | NR         | Retrospective | 19.4                   | 1 (66)                             | Various   | -                         | TKI (100)          | MVA            | MVA           | 6       |
| Author/year    | N° pts | Disease | Median age (years) | PS 0-1 (%) | Type of study | Median follow up (months) | Definition of OM (n° of lesions)/% | Site of OM | De novo / metachronous (%) | Treatment for OM (%) | OS (UVA or MVA) | PFS (UVA or MVA) | Quality |
|---------------|--------|---------|-------------------|------------|---------------|--------------------------|-------------------------------------|-----------|----------------------------|---------------------|----------------|----------------|---------|
| Ishihara/2017 | 118    | RCC     | NR                | NR         | Retrospective | NR                       | 1 (NR)                              | Various   | 100/0                      | S                   | UVA            | -              | 5       |
| Keizman/2014  | 278    | RCC     | 63                | NR         | Retrospective | 55                       | 1 (18)                              | Various   | 82/18                      | TKI ± S             | UVA            | UVA           | 8       |
| Kim/2017      | 177    | RCC     | 62                | 92.6       | Retrospective | 19.2                     | 1-3 (NR)                            | Various   | -                          | TKI (100)           | MVA            | UVA           | 6       |
| Kwak/2007     | 186    | RCC     | 58                | 86.5       | Retrospective | 17.4                     | 1 (60.2)                            | Various   | 39.8/60.2                  | S ± ICIs            | MVA            | MVA           | 6       |
| Kwak/2007 (2) | 252    | RCC     | NR                | 61         | Retrospective | 17                       | 1 (37)                              | Various   | 19/80                      | ICIs               | MVA            | MVA           | 6       |
| Liu/2017      | 266    | RCC     | 61                | NR         | Retrospective | 12                       | 1 (43)                              | Various   | -                          | S (100)            | MVA            | -             | 6       |
| Lu/2016       | 67     | RCC     | 58                | 95.5       | Retrospective | NR                       | 1-4 (32.8)                          | Bone      | -                          | TKI (100)           | MVA            | -             | 5       |
| Richey/2011   | 188    | RCC     | 60.8              | 65         | Retrospective | 6.9                      | 1 (36)                              | Various   | 100/0                      | S + Systemic tx (100) | MVA            | -             | 6       |
| Schmidt/2005  | 321    | RCC     | 51                | NR         | Retrospective | 52                       | 1-2 (60)                            | Various   | -                          | Citokines (100)     | UVA            | -             | 7       |
| Sharma/2015   | 93     | RCC     | 61                | NR         | Retrospective | 13                       | 1 (60)                              | Various   | 100/0                      | S + Systemic tx (100) | MVA            | -             | 6       |
| Takagi/2019   | 71     | RCC     | 66                | 99         | Retrospective | NR                       | 1 (45)                              | Various   | -                          | TKI (100)           | MVA            | -             | 5       |
| Thiery-       | 224    | RCC     | 67                | 82         | Retrospective | 18.3                     | 1 (51)                              | Various   | -                          | Systemic tx ± S (100) | UVA            | -             | 6       |
| Vu/2016       | 325    | RCC     | NR                | NR         | Retrospective | NR                       | 1 (37)                              | Various   | 55/45                      | S ± CT              | MVA            | MVA           | 5       |
| Zhang/2019    | 287    | RCC     | 56                | NR         | Retrospective | 28                       | 1 (53)                              | Various   | -                          | S (100)            | MVA            | MVA           | 6       |
| Dudek/2019    | 33     | Sarcoma | 55                | NR         | Retrospective | 37                       | 1-3 (72.7)                          | Lung      | 36/64                      | S (100)            | UVA            | -             | 7       |
| Kawamoto/2020 | 98     | Sarcoma | NR                | NR         | Retrospective | NR                       | 1-2 (43.9)                          | Lung      | -                          | Various             | MVA            | (PMS)         | 6       |
| Nataraj/2016  | 102    | Sarcoma | 18                | 60         | Retrospective | 23                       | 1-3 (31)                            | Lung      | 31/69                      | S ± CT (100)         | MVA            | MVA           | (EFS)   |
| Shoushtari/2016| 215    | Sarcoma | 56                | 26         | Retrospective | 175                      | 1-2 (67)                            | Various   | 39/61                      | CT (100)            | MVA            | UVA           | 9       |
| Stephens/2011 | 81     | Sarcoma | 43.5              | NR         | Retrospective | 27                       | 1-2 (33)                            | Lung      | -                          | S (100)            | MVA            | -             | 7       |
| Han/2011      | 61     | SCLC    | 65                | 71         | Phase 2       | 33.6                     | 1-2 (NR)                            | Various   | -                          | CT (100)            | MVA            | -             | 7       |
| Shirasawa/2019| 141    | SCLC    | 70                | 62         | Retrospective | NR                       | 1-5 (34.7)                          | Various   | 100/0                      | CT (100)            | MVA            | -             | 5       |
| Anraku/2003   | 133    | Utherine| 56                | NR         | Retrospective | 40                       | 1 (58)                              | Lung      | 6/94                       | S (100)            | MVA            | -             | 7       |
| Bartosch/2016 | 130    | Utherine| 52                | NR         | Retrospective | 48                       | 1 (54)                              | Various   | -                          | Various             | MVA            | -             | 7       |
| Chen/2019     | 3981   | Various | 60.84             | 40.8       | Retrospective | 44.3                     | 1 (16.5)                            | Various   | -                          | Various (100)       | MVA            | -             | 7       |
| de Baere/2015 | 566    | Various | 62.7              | NR         | Retrospective | 35.5                     | 1-2 (78)                            | Lung      | -                          | RFA (100)           | MVA            | MVA           | 7       |
| Author/year | N pts | Disease | Median age (years) | PS 0-1 (%) | Type of study | Median follow up (months) | Definition of OM (% of lesions)/% | Site of OM | De novo / metachronous (%) | Treatment for OM (%) | OS (UVA or MVA) | PFS (UVA or MVA) | Quality |
|-------------|-------|---------|-------------------|------------|---------------|--------------------------|-----------------------------------|-----------|---------------------------|-------------------|----------------|----------------|---------|
| Derde/2016  | 251   | Various | 52                | NR         | Retrospective | 10.5                     | 1-2 (40)                          | Various   | -                         | ICIs (100)        | MVA            | -              | 6       |
| Silva/2019  | 61    | Various | 66.3              | NR         | Retrospective | 13.58                   | 1-5 (35)                          | Spine     | -                         | SBRT (100)        | -              | MVA (LC 1y)    | 6       |

*M1b single extratoracic organ; CNS, central nervous system; CRC, colorectal cancer; CT, chemotherapy; DMFS, distant metastasis-free survival; DSS, disease-specific survival; EFS, event-free survival; HAI, hepatic artery infusion; HCC, hepatocellular carcinoma; ICIs, immune checkpoint inhibitors; LNs, lymph nodes; MVA, multivariate analysis; MWA, microwave ablation; NPC, nasopharyngeal carcinoma; NSCLC, non-small-cell lung cancer; OM, oligometastatic disease; OS, overall survival; OT, ormonotherapy; PFS, progression-free survival; PMS, post-metastasis survival; PRS, postrelapse survival; PS, performance status; RCC, renal cell carcinoma; RFA, radiofrequency ablation; RFS, relapse-free survival; RTDS, recurrence to death survival; S, surgery; RT, radiotherapy; SBRT, stereotactic body radiotherapy; SCLC, small-cell lung cancer; SRS, stereotactic radiosurgery; TACE, transarterial chemoembolization; TKI, tyrosine kinase inhibitor; TTP, time to progression; TTR, time to recurrence; tx, therapy; UVA, univariate analysis.
Figure 2. Progression-free survival of oligo- compared to non-oligometastatic cancers.
Progression-free survival was better in patients with OM disease (HR = 0.62, 95% CI 0.57–0.68; P < .01; n = 69 studies; Figure 2). Additionally, in the OS analysis, OM cancers were associated with a better OS (HR = 0.65, 95% CI 0.62–0.68; P < .01; n = 161 studies; Figure 3). Results were significant for all analyzed disease subgroups except biliary tract cancer and cervical cancer (only three studies included). In colorectal (CRC), breast, non-small cell lung cancer (NSCLC) and renal cell carcinoma (RCC), which constituted the more representative series, the reduction in the risk of death for OM patients were 35, 38, 30 and 42%, respectively (Figure 3). Timing of onset (synchronous vs metacronous disease) did not influence the risk of death. Most studies reported OS analysis for up to three metastases (152 out of 161 studies). After exclusion of eight studies that reported outcomes for up to five metastases the final results remained unchanged (HR = 0.64, 95% CI 0.61–0.67; P < .01). No cut-off was associated with a better outcome (1 vs 2 vs 1-2 vs 1-3 metastases).

Risk of bias through Begg’s funnel plot was not significant for the OS analysis. Conversely, Egger’s test showed evidence of bias (P < .01) (Figure 4). Trim and Fill analysis incorporated 29 missing studies. The overall effect measure (95% CI) based on this analysis was 0.7 (0.67-0.73), which became slightly weaker compared to the originally reported overall effect measure. Compared with cancers with more than three to five metastases, high-certainty evidence indicates OM tumors are associated with better prognosis in particular for CRC, breast, NSCLC and RCC. Despite the subgroup difference is not significant likely for less studies included in other groups, the results for these 4 cancers remain robust.

Discussion
The definition of oligometastatic refers to malignancies with a limited metastatic spread which may be amenable of radical treatment for both primary and each distant site, and that generally have a better prognosis compared to polymetastatic cancers. A very recently published paper clearly explains the timely clonal evolution of somatic mutations and consequently the metastatic process of many cancer types. It may be hypothesized that OM cancer is associated with a more indolent spread and therefore may represent a less fatal disease. With the expansion of the oncological armamentarium, many efforts have been made over the years to improve outcomes of patients with minimal metastatic

| Study or Subgroup | log[Hazard Ratio] | SE | Weight | Hazard Ratio IV, Random, 95% CI | Hazard Ratio IV, Random, 95% CI |
|-------------------|------------------|----|--------|-------------------------------|-------------------------------|
| **1.1.1 Biliary tract** | | | | | |
| Park 2017 | 0.4799 | 0.2141 | 0.09 | 0.64 (0.42, 0.67) | |
| Smart 2019 | 0.3365 | 0.3464 | 0.30 | 1.40 (0.71, 2.78) | |
| Subtotal (95% CI) | | | 0.09 | 0.90 (0.42, 1.94) | |
| Heterogeneity: Tau² = 0.22; Chi² = 2.71, df = 1 (P = 0.06); I² = 73% | | | | |
| Test for overall effect: Z = 2.63 (P = 0.01) | | | | |
| **1.1.2 Breast** | | | | | |
| Bates 2011 | -0.4621 | 0.1387 | 0.09 | 0.63 (0.48, 0.63) | |
| Blanchette 2018 | -0.7423 | 0.2983 | 0.30 | 0.49 (0.27, 0.84) | |
| Co 2019 | 1.1840 | 0.4026 | 0.09 | 3.27 (1.27, 8.42) | |
| Galle Bladder 2018 | -0.2231 | 0.1015 | 0.09 | 0.80 (0.70, 0.92) | |
| Ivars Rubio 2019 | -0.3639 | 0.1655 | 0.09 | 0.53 (0.39, 0.72) | |
| Jikawa 2019 | -0.5708 | 0.4323 | 0.20 | 0.56 (0.24, 1.31) | |
| Vogler 2006 | -0.5779 | 0.1445 | 0.09 | 0.50 (0.44, 0.78) | |
| Lecocq 2017 | -0.8218 | 0.1195 | 0.09 | 0.44 (0.34, 0.57) | |
| Le Scan 2009 | -0.47 | 0.1139 | 1.00 | 0.63 (0.50, 0.78) | |
| Lipton 2010 | -0.5978 | 0.0802 | 1.00 | 0.55 (0.47, 0.64) | |
| Lobbezeau 2015 | -0.8444 | 0.1998 | 1.00 | 0.43 (0.34, 0.54) | |
| Neumann 2010 | 0.1923 | 0.3296 | 0.30 | 1.20 (0.62, 2.33) | |
| Nguyen 2012 | -0.6733 | 0.1240 | 1.00 | 0.51 (0.40, 0.65) | |
| Nikura 2012 | -0.734 | 0.0725 | 0.10 | 0.48 (0.26, 0.82) | |
| Park 2009 | 0.01 | 0.1863 | 0.09 | 1.01 (0.73, 1.40) | |
| Pons-Tostiv 2010 | -0.4569 | 0.0617 | 1.00 | 0.63 (0.56, 0.71) | |
| Rho 2014 | -0.4829 | 0.2199 | 0.09 | 0.62 (0.40, 0.95) | |
| Weng 2019 | -0.3567 | 0.3407 | 0.30 | 0.70 (0.36, 1.38) | |
| Subtotal (95% CI) | | | 0.37 | 0.62 (0.54, 0.72) | |
| Heterogeneity: Tau² = 0.08; Chi² = 124.07, df = 17 (P < 0.00001); I² = 86% | | | | |
| Test for overall effect: Z = 0.51 (P = 0.00001) | | | | |
| **1.1.3 Bladder** | | | | | |
| Luzzago 2019 | 0.5978 | 0.1024 | 1.10 | 0.55 (0.45, 0.67) | |
| Subtotal (95% CI) | | | 1.10 | 0.55 (0.45, 0.67) | |
| Heterogeneity: Not applicable | | | | |
| Test for overall effect: Z = 5.94 (P < 0.00001) | | | | |
| **1.1.4 Cervix** | | | | | |
| Yin 2019 | -0.2405 | 0.3159 | 0.40 | 0.79 (0.42, 1.49) | |
| Subtotal (95% CI) | | | 0.40 | 0.78 (0.42, 1.45) | |
| Heterogeneity: Not applicable | | | | |
| Test for overall effect: Z = 0.79 (P = 0.43) | | | | |

Figure 3. Overall survival of oligo- compared to non-oligometastatic cancers.
1.1.5 Colorectal

| Study         | Tau       | Heterogeneity |
|---------------|-----------|---------------|
| Afshari 2019  | -0.0875   |               |
| Aminakura 2017| -0.2744   |               |
| Aparicio 2015 | -0.4308   |               |
| Bachtel 2019  | -0.4621   |               |
| Baldis 2021   | -0.2744   |               |
| Beppu 2014    | -0.2495   |               |
| Blazier II 2008| -0.4403  |               |
| Bollig 2020   | -0.3426   |               |
| Bosse'2020    | -0.0513   |               |
| Cardona 2013  | -0.1585   |               |
| Catalano 2008 | -0.3671   |               |
| Chen 2010     | -0.821    |               |
| Cornella 2005 | -0.3725   |               |
| Creasey 2018  | -0.2485   |               |
| Cristofal 2014| -0.2321   |               |
| Dai 2020      | -0.6733   |               |
| Daniel 2017   | -0.9918   |               |
| de Guis-Oel 2006| -0.2018  |               |
| Efficace 2008 | -0.1287   |               |
| Faron 2015    | -0.6425   |               |
| Fujikawa 2020 | -0.2289   |               |
| Graftinghe 2014| -0.0013  |               |
| Ogi 2019      | -0.4297   |               |
| Ogi 2020      | -0.4463   |               |
| Hernandez 2016| -0.1863   |               |
| Holliday 2017 | -0.1392   |               |
| Huang 2020    | -1.1384   |               |
| Ichiguro2009  | -0.6733   |               |
| Kawamoto 2020 | -0.3711   |               |
| Koegepe 2009  | -0.5329   |               |
| Leal 2016     | -0.0834   |               |
| Lin 2018      | -0.4463   |               |
| Liu 2010      | 0.207     |               |
| Liu 2015      | -0.2221   |               |
| Liu 2020      | -1.0217   |               |
| Liu 2020 (D) | -0.0726   |               |
| Margonis 2015 | -0.1744   |               |
| Margonis 2017 | -0.3229   |               |
| Margonis 2019 | -0.323    |               |
| Mise 2016     | -0.1827   |               |
| Miyamoto 2015 | -0.2771   |               |
| Montes 2020   | -1.2737   |               |
| Negri 2005    | -0.4308   |               |
| Neovitri 2015 | -0.5447   |               |
| Neron 2020    | -1.0498   |               |
| Njegia 2011   | -1.0952   |               |
| Park 2016     | -0.2744   |               |
| Parkin 2013   | -0.4308   |               |
| Peng 2017     | -0.361    |               |
| Prasanna 2020 | -0.4308   |               |
| Ran 2020      | -1.4271   |               |
| Riu 2017      | -0.1278   |               |
| Rozzi 2012    | -0.2627   |               |
| Sasaki 2016   | -0.734    |               |
| Sasaki 2017   | -0.4959   |               |
| Shimizu 2019  | -0.4852   |               |
| Shinozaki 2020| -0.1744   |               |
| Souglakos 2009| -0.9163   |               |
| Stang 2016    | -0.9943   |               |
| Stremitzer 2015| -0.9797   |               |
| Tambo 2020    | -1.3093   |               |
| Tanggaard 2014| -0.3711   |               |
| Van Cutsem 2004| -0.2614   |               |
| Wang 2017     | -0.3587   |               |
| Yee 2018      | -0.3425   |               |
| Xie 2018      | -0.755    |               |
| Yamaishi 2017 | -0.0675   |               |
| Zhang 2020    | -0.7765   |               |
| Zhao 2018     | -0.4308   |               |

**Subtotal (95% CI)**

-42.8% [6.65, 0.61, 0.70]

Test for overall effect: Z = 2.53 (P = 0.030001)

**Figure 3. (continued)**
1.1.6 Esophageal

| Study Year | Odds Ratio | 95% CI | P-value |
|------------|------------|--------|---------|
| A1 2017    | -1.1712    | 0.3085 | 0.4%    | 0.31 [0.17, 0.57] |

Subtotal (95% CI) 0.4% 0.31 [0.17, 0.57]

Heterogeneity: Not applicable

Test for overall effect: Z = 3.82 (P = 0.0001)

1.1.7 Gastric

| Study Year | Odds Ratio | 95% CI | P-value |
|------------|------------|--------|---------|
| Hashimoto 2010 | -0.6162    | 0.1531 | 0.9%    | 0.54 [0.40, 0.73] |
| Kodokura 2013  | -0.4463    | 0.1797 | 0.7%    | 0.64 [0.45, 0.81] |
| Kim JG 2008   | -0.1912    | 0.1594 | 0.9%    | 0.83 [0.60, 1.13] |
| Kimura 2016   | -0.4005    | 0.2566 | 0.5%    | 0.67 [0.41, 1.09] |
| Kinosita 2015 | -0.8463    | 0.1766 | 0.7%    | 0.43 [0.30, 0.62] |
| Konohata 2018 | -0.5152    | 0.3245 | 0.3%    | 0.85 [0.45, 1.61] |
| Wang 2016     | -0.3857    | 0.1488 | 0.9%    | 0.68 [0.51, 0.81] |
| Wang 2018     | -0.3425    | 0.1396 | 0.9%    | 0.71 [0.54, 0.93] |

Subtotal (95% CI) 5.7% 0.65 [0.56, 0.75]

Heterogeneity: Tau² = 9.01; CI² = 9.83, df = 7 (P = 0.20); I² = 29%

Test for overall effect: Z = 5.86 (P < 0.0001)

1.1.8 Head & Neck

| Study Year | Odds Ratio | 95% CI | P-value |
|------------|------------|--------|---------|
| Jiang 2015 | -0.0619    | 0.2062 | 0.9%    | 0.94 [0.63, 1.41] |
| Lo 2017    | -0.2744    | 0.1242 | 0.5%    | 0.70 [0.47, 1.02] |
| Nishiyama 2017 | -0.2405 | 0.1876 | 0.7% | 0.76 [0.54, 1.13] |
| Shen L 2015 | -0.47     | 0.1676 | 0.8% | 0.63 [0.45, 0.87] |
| Shen L 2015 | -0.47     | 0.1676 | 0.8% | 0.63 [0.45, 0.87] |

Subtotal (95% CI) 3.4% 0.72 [0.61, 0.85]

Heterogeneity: Tau² = 0.00; CI² = 3.29, df = 4 (P = 0.51); I² = 0%

Test for overall effect: Z = 3.94 (P < 0.0001)

1.1.9 HCC

| Study Year | Odds Ratio | 95% CI | P-value |
|------------|------------|--------|---------|
| Mazzaferris 2009 | -0.4155 | 0.1119 | 1.0% | 0.86 [0.53, 0.82] |
| Yoon 2010    | -0.2814    | 0.7297 | 0.1%    | 0.77 [0.18, 3.21] |

Subtotal (95% CI) 1.1% 0.66 [0.53, 0.82]

Heterogeneity: Tau² = 0.00; CI² = 0.04, df = 1 (P = 0.63); I² = 0%

Test for overall effect: Z = 3.72 (P = 0.002)

1.1.10 Melanoma

| Study Year | Odds Ratio | 95% CI | P-value |
|------------|------------|--------|---------|
| Bland 2016 | -0.3293    | 0.1688 | 0.7%    | 0.72 [0.50, 1.04] |
| Iacono 2019 | 0.1484 | 0.2279 | 0.3% | 1.16 [0.81, 2.21] |
| Lee 2009    | -0.2627    | 0.0267 | 1.4%    | 0.77 [0.73, 0.81] |
| Moreau 2012 | -0.7986    | 0.2078 | 0.4%    | 0.45 [0.26, 0.79] |
| Geremert 2019 | -0.0875 | 0.3941 | 0.2% | 0.42 [0.10, 0.81] |
| Vlachos 2012 | -0.4155 | 0.1732 | 0.7% | 0.86 [0.47, 0.93] |

Subtotal (95% CI) 3.9% 0.71 [0.59, 0.85]

Heterogeneity: Tau² = 0.02; CI² = 0.16, df = 5 (P = 0.15); I² = 39%

Test for overall effect: Z = 3.75 (P = 0.0002)

1.1.11 Neuroendocrine

| Study Year | Odds Ratio | 95% CI | P-value |
|------------|------------|--------|---------|
| Robelin 2019 | -0.1908 | 0.4317 | 0.2% | 0.86 [0.37, 2.00] |

Subtotal (95% CI) 0.2% 0.86 [0.37, 2.00]

Heterogeneity: Not applicable

Test for overall effect: Z = 0.35 (P = 0.73)

1.1.12 NSCLC

| Study Year | Odds Ratio | 95% CI | P-value |
|------------|------------|--------|---------|
| Beau-Faller 2019 | -0.9163 | 0.2189 | 0.9% | 0.40 [0.26, 0.62] |
| Ding 2017    | -0.4787    | 0.3537 | 0.3%    | 0.62 [0.31, 1.24] |
| Li 2018      | -0.47     | 0.3416 | 0.3%    | 0.63 [0.32, 1.23] |
| Liu 2018     | -0.3726    | 0.2409 | 0.5%    | 0.93 [0.50, 1.74] |
| Nishi 2016   | -0.7895    | 0.5665 | 0.1%    | 0.45 [0.15, 1.35] |
| Pacagnella 2006 | -0.2814 | 0.1534 | 0.8% | 0.77 [0.57, 1.04] |
| Park 2019    | -0.4787    | 0.3537 | 0.3%    | 0.62 [0.31, 1.24] |
| Shin 2018    | -0.2744    | 0.1206 | 1.0%    | 0.76 [0.60, 0.98] |
| Speduto 2016 | -0.3185    | 0.0968 | 1.2%    | 0.82 [0.71, 0.95] |
| Takahashi 2019 | -0.3011 | 0.3876 | 0.3% | 0.74 [0.36, 1.52] |

Subtotal (95% CI) 6.4% 0.78 [0.60, 0.98]

Heterogeneity: Tau² = 0.02; CI² = 17.08, df = 9 (P = 0.00); I² = 47%

Test for overall effect: Z = 4.94 (P < 0.00001)

Figure 3. (continued)
### 1.1.13 Pancreatic

| Study     | BNP | 95% CI  | Test for overall effect: Z = 2.81 (P = 0.009) |
|-----------|-----|---------|---------------------------------------------|
| Bolm 2015 | -0.7969 | 0.3061 | 0.4% | 0.45 (0.25, 0.62) |
| Subtotal (95% CI) | 0.4% | 0.45 (0.25, 0.62) |

### 1.1.14 Prostate

| Study     | BNP | 95% CI  | Test for overall effect: Z = 3.49 (P = 0.0000) |
|-----------|-----|---------|---------------------------------------------|
| Armstrong 2007 | -0.4943 | 0.144 | 0.9% | 0.61 (0.46, 0.81) |
| Tablazon 2019 | -0.478 | 0.797 | 0.1% | 0.62 (0.13, 2.96) |
| Subtotal (95% CI) | 1.0% | 0.61 (0.46, 0.81) |

### 1.1.15 RCC

| Study     | BNP | 95% CI  | Test for overall effect: Z = 3.28 (P = 0.00001) |
|-----------|-----|---------|---------------------------------------------|
| Antal 2011 | 0.077 | 0.1262 | 1.0% | 1.99 (0.04, 1.99) |
| Abtoder 2013 | -0.3429 | 0.1599 | 0.8% | 0.71 (0.52, 0.97) |
| Beuselinck 2014 | -0.4308 | 0.2606 | 0.5% | 0.65 (0.39, 1.08) |
| Cal 2017 | -0.5108 | 0.2199 | 0.6% | 0.60 (0.39, 0.92) |
| Fay 2018 | 0.4253 | 0.1114 | 1.0% | 1.53 (0.23, 1.65) |
| Forabashish 2017 | -1.0871 | 0.5708 | 0.1% | 0.15 (0.05, 0.48) |
| Gla 2017 | -0.3289 | 0.2368 | 0.5% | 0.72 (0.45, 1.15) |
| Ikeda 2018 | -0.7989 | 0.2606 | 0.5% | 0.45 (0.27, 0.75) |
| Ishihara 2017 | -0.0539 | 0.3945 | 0.2% | 0.52 (0.24, 1.13) |
| Kehlman 2014 | -0.0513 | 0.1782 | 0.7% | 0.95 (0.67, 1.35) |
| Kim SH 2017 | -0.7989 | 0.2421 | 0.5% | 0.45 (0.28, 0.72) |
| Kivac 2007 | -0.564 | 0.4005 | 0.2% | 0.57 (0.26, 1.29) |
| Kivac 2007 (2) | -0.844 | 0.2975 | 0.4% | 0.43 (0.24, 0.77) |
| Liu 2017 | -1.4271 | 0.275 | 0.4% | 0.24 (0.14, 0.41) |
| Lu 2015 | -1.2413 | 0.4975 | 0.2% | 0.29 (0.11, 0.77) |
| Richey 2011 | -3.5682 | 0.2167 | 0.8% | 0.50 (0.30, 0.88) |
| Schmidt 2005 | -0.47 | 0.1139 | 1.0% | 0.82 (0.50, 0.78) |
| Sharma 2015 | -0.755 | 0.2843 | 0.5% | 0.47 (0.28, 0.79) |
| Takagi 2019 | -1.3471 | 0.4389 | 0.2% | 0.26 (0.11, 0.61) |
| Thiery-Vulliermin 2017 | -0.3945 | 0.1524 | 0.9% | 0.87 (0.50, 0.91) |
| Yannamoli 2018 | -0.844 | 0.4167 | 0.2% | 0.43 (0.10, 0.97) |
| You 2016 | -0.734 | 0.1612 | 0.9% | 0.40 (0.35, 0.66) |
| Zhang 2019 | -0.1744 | 0.1802 | 0.7% | 0.84 (0.50, 1.20) |
| Subtotal (95% CI) | 12.8% | 0.58 (0.47, 0.71) |

### 1.1.16 Sarcoma

| Study     | BNP | 95% CI  | Test for overall effect: Z = 3.07 (P = 0.002) |
|-----------|-----|---------|---------------------------------------------|
| Dudel 2019 | -0.7905 | 0.4967 | 0.2% | 0.45 (0.17, 1.19) |
| Nataraj 2016 | -1.5141 | 0.5161 | 0.2% | 0.22 (0.00, 0.60) |
| Shouhrt 2016 | -0.4005 | 0.1596 | 0.9% | 0.87 (0.49, 0.92) |
| Stephens 2011 | -0.4943 | 0.3135 | 0.4% | 0.81 (0.33, 1.33) |
| Subtotal (95% CI) | 1.1% | 0.54 (0.37, 0.80) |

### 1.1.17 SCLC

| Study     | BNP | 95% CI  | Test for overall effect: Z = 5.80 (P = 0.00001) |
|-----------|-----|---------|---------------------------------------------|
| Han 2011 | -0.7965 | 0.2989 | 0.4% | 0.45 (0.25, 0.61) |
| Shirasawa 2019 | -0.5798 | 0.1118 | 1.0% | 0.58 (0.45, 0.70) |
| Subtotal (95% CI) | 1.4% | 0.55 (0.44, 0.67) |

### 1.1.18 Uterine

| Study     | BNP | 95% CI  | Test for overall effect: Z = 3.27 (P = 0.001) |
|-----------|-----|---------|---------------------------------------------|
| Anraku 2003 | -0.5108 | 0.4074 | 0.2% | 0.60 (0.27, 1.33) |
| Bartosch 2016 | -0.7765 | 0.2533 | 0.5% | 0.40 (0.28, 0.78) |
| Subtotal (95% CI) | 0.7% | 0.50 (0.32, 0.76) |

### 1.1.19 Other

| Study     | BNP | 95% CI  | Test for overall effect: Z = 0.47 (P = 0.638) |
|-----------|-----|---------|---------------------------------------------|
| Chen 2019 | -0.4006 | 0.0439 | 1.4% | 0.87 (0.61, 0.73) |
| de Baere 2015 | -0.4929 | 0.1725 | 0.0% | 0.62 (0.44, 0.79) |
| Dercie 2016 | -0.0408 | 0.2842 | 0.4% | 0.80 (0.55, 1.05) |
| Subtotal (95% CI) | 2.5% | 0.67 (0.52, 0.73) |

### Figure 3. (continued)
Advance in imaging may also have improved in the last years the diagnosis of oligometastases with the possibility of a more targeted approach toward primary tumor and every single oligometastatic site. This may have created a bias compared to older series, where less accurate imaging modalities were available and more frequent cases of oligometastases could now be overdiagnosed.

We have performed the most exhaustive systematic review of the literature to quantify the prognostic value of OM stage in various cancers. Overall, OM cancer patients have a risk of death and progression that is a third less than the polymetastatic counterpart. The OM state is frequently calculated as an independent favorable prognostic variable, which means that these patients do well independent from other clinical-pathological characteristics. The effect size was calculated from 173 studies including more than 100,000 patients. The final results were similar in all the most frequent histologies including CRC, breast cancer, NSCLC, RCC and sarcoma with inferior survival in OM gastric, melanoma and head and neck cancers.

Prognosis of OM cancer may be also different according to site of oligometastases. For example in CRC, breast and RCC lung metastases have a generally more favourable outcome than liver (or peritoneal ones in CRC). In our series, sites of oligometastases were mixed or not described at all so a subgroup analysis was not performed.12

There is also evidence from randomized clinical trials13-15 that ablative therapies improve survival in patients with OM cancer. For example, in some cancers small randomized studies3-21 already provide evidence of survival improvement in patients that received both systemic and local therapies compared to those that received systemic therapies alone. As a matter of fact, resection of colorectal cancer liver metastases nowadays represents an essential curative option and a primary endpoint in multiple clinical trials.13 Furthermore, Gomez et al.14 found that in OM NSCLCs, adding local consolidative therapy to active oligometastases and to primary disease may improve OS from 17 to 41 months. Also, in RCC the treatment of indolent lung metastases may permit delaying the start of systemic treatment and obtain an excellent control.15 A large burden of evidence now supports local therapy for minimal oligoprogressive cancers treated with targeted therapies or immunotherapy. Here, metastases-directed therapy could delay the switch of systemic therapy by radical local treatment of all progressive metastatic sites.16,17 With the advent of immunotherapy, the combination of immune check point inhibitors and radiotherapy to single OM lesions may facilitate a potentiation of the immune response, increasing the chances of achieving an abscopal effect. This term describes an event in which focalized radiotherapy discharge systemic anti-tumoral action that can result in distant responses.18 For example, in lung cancer the combination has a good safety profile and achieves high rates of local control and greater chances of obtaining abscopal responses than radiotherapy alone, with a relevant impact on outcome.19 Oligometastatic cancers can also regarded as extended locoregional disease if, after proper conversion therapy, all sites of metastases and primary tumor may be radically resected with curative purposes. Such a strategy has been employed in largely incurable cancers as gastric and pancreatic carcinomas where selected cases with small liver-limited recurrences were managed with surgery.20,21

Figure 4. Funnel plot of publication bias for overall survival analysis showing standard error by log hazard ratio.
Melanoma and head and neck OM cancers are also associated with better prognosis. In these settings isolated recurrences (lymph nodes, lung nodules or brain metastases) may be radically treated with surgery or radiotherapy.

This meta-analysis has several limitations. First, our review does not evaluate the absolute benefit of any local treatment and the prognosis and management of oligoprogressive disease or down staged polymetastases to an OM state. Second, the literature search covered a large lifetime span and may include older series where radiological evaluation did not include more advanced modalities that can now increase the accuracy of oligometastases detection. Third, most of studies have an observational design and outcome was retrospectively analysed. Likely publication bias may influenced the prognosis of this population. Finally, the optimal number of lesions defining the OM state cannot be defined in this paper.

A consensus paper of EORTC and ESTRO societies attempted to provide definitions of various OM conditions either naïve or attained after therapy and either synchronous or metachronous.

Some large, randomized studies have included local therapies for OM cancers. An NRG Oncology randomized phase II/III trial study compares therapy with stereotactic radiosurgery and/or surgery with standard of care therapy alone in treating patients with breast cancer that has one or two locations in the body (limited metastatic) that are previously untreated. The PREST study will assess the efficacy of ablative radiotherapy (stereotactic body radiotherapy applied to all oligometastases) administered to all tumor sites (metastases and prostate if applicable), in oligometastatic hormone-sensitive prostate cancer patients. Finally, an ECOG-ACRIn phase III study compared standard chemotherapy to consolidative radiotherapy in patients with oligometastatic HER2 negative esophageal and gastric adenocarcinoma (https://clinicaltrials.gov/ct2/show/NCT02364557; https://clinicaltrials.gov/ct2/show/NCT04115007; https://clinicaltrials.gov/ct2/show/NCT04248452). In all ongoing studies the aim is the optimal timing (after a good shrinkage during systemic therapy) and integration of systemic medical therapy and local ablation/resection with the scope of improving long-term survivals.

Conclusions
In conclusion, this meta-analysis tried to quantify the prognosis associated with OM compared to cancers with more extensive diffusion. Based on our findings, we suggest that every metastatic patient should be accurately evaluated for the number of distant sites of disease, and a treatment strategy that involves both the primary and the metastases should be carefully considered. Patients could be reassured about their life expectancy and about the possibility of integrate both systemic and local therapy with the hope, in certain cases, for definitive cure. In others, focal treatment on the metastases may delay the immediate use of more toxic drugs (for example in elderly or indolent diseases). Also, we propose that these patients should be stratified when included in clinical trials and dedicated studies should be designed.

Data availability
Extended data
Mendeley Data: Extended data for ‘Better survival of patients with oligo- compared with polymetastatic cancers: a systematic review and meta-analysis of 173 studies’.

http://dx.doi.org/10.17632/8kycvdnp6v.1.10

This project contains the following extended data:

Supplementary Table 1: List of included studies.

Reporting guidelines
Mendeley Data: PRISMA checklist for ‘Better survival of patients with oligo- compared with polymetastatic cancers: a systematic review and meta-analysis of 173 studies’.

http://dx.doi.org/10.17632/8kycvdnp6v.1.10

Data are available under the terms of the Creative Commons Attribution 4.0 license (CC-BY 4.0).
References

1. Hellman S, Weichselbaum RR: Oligometastases. J Clin Oncol. 1995; 13(3): 8–10. PubMed Abstract | Publisher Full Text
2. Weichselbaum RR, Hellman S: Oligometastases revisited. Nat Rev Clin Oncol. 2011; 8(6): 378–382. PubMed Abstract | Publisher Full Text
3. Chalkidou A, Macmillan T, Grzeda MT, et al: Stereotactic ablative body radiotherapy in patients with oligometastatic cancers: a prospective, registry-based, single-arm, observational, evaluation study. Lancet Oncol. 2021 Jan; 22(1): 98–106. PubMed Abstract | Publisher Full Text
4. Donini M, Buti S, Massari F, et al: Management of oligometastatic and oligo-progressive renal cell carcinoma: state of the art and future directions. Expert Rev Anticancer Ther. 2020 Jun; 20(6): 491–501. Epub 2020 Jun 1. PubMed Abstract | Publisher Full Text
5. Glicksman RM, Metser U, Vines D, et al: Curative-intent Metastasis-directed Therapies for Molecularly-defined Oligorecurrent Prostate Cancer: A Prospective Phase II Trial Testing the Oligometastasis Hypothesis. Eur Urol. 2021 Mar 5; S0302-2838(21)00151-2. Epub ahead of print. PubMed Abstract | Publisher Full Text
6. Palma DA, Olson R, Harrow S, et al: Stereotactic ablative radiotherapy versus standard of care palliative treatment in patients with oligometastatic cancers (SABR-COMET): a randomised, phase 2, open-label trial. Lancet. 2019 May 18; 393(10185): 2051–2058. PubMed Abstract | Publisher Full Text
7. Beggs CB, Mazumdar M: Operating Characteristics of A Bank Correlation Test for Publication Bias, Biometrics. 1994; 50(4): 1088–1101. PubMed Abstract
8. Shi L, Lin L, Omboni S: The trim-and-fill method for publication bias: Practical guidelines and recommendations based on a large database of meta-analyses. Med (United States). 2019. PubMed Abstract | Publisher Full Text | Free Full Text
9. Review Manager (RevMan) [Computer program]: Version 5.3. Copenhagen: The Nordic Cochrane Centre, The Cochrane Collaboration; 2014.
10. Petrelli F, et al: Better survival of patients with oligo- compared with polymetastatic cancers: a systematic review and meta-analysis of 173 studies. Mendeley Data. 2021. Publisher Full Text
11. Gerstung M, Jolly C, Leshchiner I, et al: The evolutionary history of 2,658 cancers. Nature. 2020 Feb; 578(7793): 122–128. Epub 2020 Feb 6. PubMed Abstract | Publisher Full Text | Free Full Text
12. Franko J, Shi Q, Meyers JP, et al: Prognosis of patients with peritoneal metastatic colorectal cancer given systemic therapy: an analysis of individual patient data from prospective randomised trials from the Analysis and Research in Cancers of the Digestive System (ARCAD) database. Lancet Oncol. 2016 Dec; 17(12): 1709–1719. PubMed Abstract | Publisher Full Text
13. Fong Y, Fortner J, Sun RL, et al: Clinical score for predicting recurrence after hepatic resection for metastatic colorectal cancer: analysis of 1001 consecutive cases. Ann Surg. 1999; 230(3): 309–321. PubMed Abstract | Publisher Full Text | Free Full Text
14. Gomez DR, Tang C, Zhang J, et al: Local Consolidative Therapy Vs. Maintenance Therapy or Observation for Patients With Oligometastatic Non-Small-Cell Lung Cancer: Long-Term Results of a Multi-Institutional, Phase II, Randomized Study. J Clin Oncol. 2019 Jun 20; 37(18): 1558–1565. Epub 2019 May 8. PubMed Abstract | Publisher Full Text | Free Full Text
15. Zhang Y, Schoenhals J, Christie A, et al: Stereotactic Ablative Radiation Therapy (SABR) Used to Defer Systemic Therapy in Oligometastatic Renal Cell Cancer. Int J Radiat Oncol Biol Phys. 2019 Oct 1; 105(2): 367–375. Epub 2019 Aug 1. PubMed Abstract | Publisher Full Text | Free Full Text
16. Kroeze SGC, Schuapel J, Fritz C, et al: Metastasis directed stereotactic radiotherapy in NSCLC patients progressing under targeted- or immunotherapy: efficacy and safety reporting from the ‘TOaSIT’ database. Radiat Oncol. 2021 Jan 6; 16(1): 4. PubMed Abstract | Publisher Full Text | Free Full Text
17. Deek MP, Taparra K, Phillips R, et al: Metastasis-directed Therapy Prolongs Efficacy of Systemic Therapy and Improves Clinical Outcomes in Oligoprogressive Castration-resistant Prostate Cancer. Eur Urol Oncol. 2020 Jun 11; S2588-9311 (20)30058-4. Epub ahead of print. PubMed Abstract | Publisher Full Text | Free Full Text
18. Mole Rj: Whole body irradiation – Radiology or medicine? Br J Radiol. 1953; 26: 234–241. PubMed Abstract | Publisher Full Text | Free Full Text
19. Chicas-Sett R, Morales-Orue I, Castilla-Martinez J, et al: Stereotactic Ablative Radiotherapy Combined with Immune Checkpoint Inhibitors Reboots the Immune Response Assisted by Immunotherapy in Metastatic Lung Cancer: A Systematic Review. Int J Mol Sci. 2019 May 2; 20(9): 2173. PubMed Abstract | Publisher Full Text | Free Full Text
20. De Simoni O, Scarpa M, Tonello M, et al: Oligometastatic Pancreatic Cancer to the Liver in the Era of Neoadjuvant Chemotherapy: Which Role for Conversion Surgery? A Systematic Review and Meta-Analysis. Cancers (Basel). 2020 Nov 17; 12(11): 3402. PubMed Abstract | Publisher Full Text | Free Full Text
21. Zhang F, Huang X, Song Y, et al: Conversion Surgery for Stage IV Gastric Cancer. Front Oncol. 2019 Nov 7; 9: 1158. PubMed Abstract | Publisher Full Text | Free Full Text
22. Guckenberger M, Lievens Y, Bouma AB, et al: Characterisation and classification of oligometastatic disease: a European Society for Radiotherapy and Oncology and European Organisation for Research and Treatment of Cancer consensus recommendation. Lancet Oncol. 2020 Jan; 21(1): e18–e28. PubMed Abstract | Publisher Full Text
Open Peer Review

Current Peer Review Status: ✅ ✅

**Version 4**

Reviewer Report 13 May 2022

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 Luca G. Campana

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The authors have satisfactorily addressed the majority of the requests, so I recommend the submission for indexing.

**Competing Interests:** No competing interests were disclosed.

**Reviewer Expertise:** General Surgery; Surgical Oncology; Clinical Research; Melanoma; Colorectal Cancer; Soft Tissue Sarcomas; Skin Cancer

I confirm that I have read this submission and believe that I have an appropriate level of expertise to confirm that it is of an acceptable scientific standard.

**Version 3**

Reviewer Report 22 November 2021

https://doi.org/10.5256/f1000research.77989.r100190

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Luca G. Campana

1 Department of Surgery, Colorectal and Peritoneal Oncology Centre, The Christie NHS Foundation
The authors of this report deserve praise for their extensive work. The data presented are intriguing and raise some intriguing questions.

- For the included studies, it would be interesting to know the comparator group and its tumour burden. This information would help to appreciate the magnitude of the differences in outcome.

- Additionally, one of the original questions raised with the introduction of the oligometastatic concept relates to the feasibility of local or locoregional treatment in a subset of patients with indolent disease. In this regard, I would present this information as a separate column in Table 1.

- Always in Table 1, the columns on OS and PFS present rather generic information. Therefore, I would suggest including the specific outcomes. Also, the column on Age and PS should be split. Finally, the content of the column “Type of study” should be homogenised.

- Further, the authors need to consider the time bias because modern imaging technologies increase the number of patients labelled as oligometastatic.

- It would be essential to distinguish between different types of oligometastatic disease (e.g., indolent progressive and minimal residual disease after previous treatments). In this regard, in Table 1, the column “De novo or metachronous” seems to provide this information, but it is not entirely clear.

- Please include the authors cited in Table 1 in the reference list.

**Minor comments**

**Abstract**

Please revise and use terms consistently (e.g. avoid “overall mortality in OM”). In addition, the conclusions should be reformulated; in particular, the last sentence should be more focused on the results presented.

**Introduction**

Please revise the language and, wherever possible, shorten the text (e.g. the first sentence is superfluous in this context). Also, please check some definitions such as “prognostic survival” and “with up to three to five metastatic sites.”

**Methods**

Please adjust the definition of polymetastatic accordingly.

**Results**

Figure 1: More than 2,000 reports were excluded from the analysis. The reason needs to be clarified.

Table 1 should indicate more clearly the prevalence of patients with oligometastatic disease.
Page 14: “Timing of onset did not influence the risk of death”. The authors should better explain this finding.

Discussion
The discussion could be improved by discussing some general issues first (challenges in the definition of OM, changing scenario in terms of diagnostic tools and available treatments) and then presenting some reflections on the cancer types where the effect of OM on OS was more prominent. For instance, the criterium of OM disease has been long applied in surgical oncology for selecting patients with lung metastases for surgical resection or patients with peritoneal carcinomatosis for cytoreduction and intraperitoneal chemotherapy.

Competing Interests: No competing interests were disclosed.

Reviewer Expertise: Surgical oncology

I confirm that I have read this submission and believe that I have an appropriate level of expertise to confirm that it is of an acceptable scientific standard, however I have significant reservations, as outlined above.

Author Response 08 May 2022
Fausto Petrelli, asst bergamo ovest, Treviglio (BG), Italy

The authors of this report deserve praise for their extensive work. The data presented are intriguing and raise some intriguing questions.

- For the included studies, it would be interesting to know the comparator group and its tumour burden. This information would help to appreciate the magnitude of the differences in outcome.
  
  **Data not available (comparator is the non-oligometastatic group but is not known site and number of metastases, for definition > 3-5 metastases).**

- Additionally, one of the original questions raised with the introduction of the oligometastatic concept relates to the feasibility of local or locoregional treatment in a subset of patients with indolent disease. In this regard, I would present this information as a separate column in Table 1.
  
  **Data not available.**

- Always in Table 1, the columns on OS and PFS present rather generic information. Therefore, I would suggest including the specific outcomes. Also, the column on Age and PS should be split. Finally, the content of the column “Type of study” should be homogenised.
  
  **OS and PFS are not generis but the exact outcomes (what is the meaning of specific outcomes?). Age and PS were split.**

- Further, the authors need to consider the time bias because modern imaging technologies increase the number of patients labelled as oligometastatic. **Sentence added in discussion.**
○ It would be essential to distinguish between different types of oligometastatic disease (e.g., indolent progressive and minimal residual disease after previous treatments). In this regard, in Table 1, the column “De novo or metachronous” seems to provide this information, but it is not entirely clear.

Data were not available. Only the information reported were extractable.

○ Please include the authors cited in Table 1 in the reference list.

Due to the high number of studies, ref list is reported in a separated file.

Minor comments

Abstract
Please revise and use terms consistently (e.g. avoid “overall mortality in OM”). In addition, the conclusions should be reformulated; in particular, the last sentence should be more focused on the results presented.

OK sentence modified.

Introduction
Please revise the language and, wherever possible, shorten the text (e.g. the first sentence is superfluous in this context). Also, please check some definitions such as “prognostic survival” and “with up to three to five metastatic sites.”

OK sentence modified. Sentences cancelled.

Methods
Please adjust the definition of polymetastatic accordingly.

OK, sentence modified.

Results
Figure 1: More than 2,000 reports were excluded from the analysis. The reason needs to be clarified.

OK reason included.

Table 1 should indicate more clearly the prevalence of patients with oligometastatic disease. Data already included in the table by the authors.

Page 14: “Timing of onset did not influence the risk of death”. The authors should better explain this finding.

OK, sentence modified.

Discussion
The discussion could be improved by discussing some general issues first (challenges in the definition of OM, changing scenario in terms of diagnostic tools and available treatments) and then presenting some reflections on the cancer types where the effect of OM on OS was more prominent. For instance, the criterium of OM disease has been long applied in surgical oncology for selecting patients with lung metastases for surgical resection or patients with peritoneal carcinomatosis for cytoreduction and intraperitoneal chemotherapy.

OK sentences added.
The authors have thoroughly addressed all my comments, resulting in a stronger paper.

**Competing Interests:** No competing interests were disclosed.

**Reviewer Expertise:** Peritoneal surface malignancies, advanced colorectal cancer

I confirm that I have read this submission and believe that I have an appropriate level of expertise to confirm that it is of an acceptable scientific standard.

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The authors present the results of their systematic review and meta-analysis assessing the prognostic impact of oligometastatic disease on adult patients with solid tumors, as compared with a more diffuse metastatic spread. Overall and progression-free survival were significantly longer in patients with 3-to-5 metastatic lesions, irrespective of anatomic site. This may sound quite obvious in modern oncology, but the authors were able to provide a large amount of clinical
data to support such an assumption.

Comments:

Abstract:
- In the Introduction, the main topic of this literature review was described concisely but exhaustively.
- In the Conclusions, please use the term "oligometastatic disease (or OM)" instead of "oligometastases".

Methods:
- The methodology of literature search and data extraction, paper selection criteria, and statistical analyses are thoroughly described. The review was carried out according to international guidelines (PRISMA). Please, clarify if papers not in English language studies were included.
- Also, the Newcastle-Ottawa Scale (NOS) might be briefly described, as a number of readers may be not familiar with it.

Results:
- In the Results section, the authors state that the reduction in the risk of death for oligometastatic patients was 35%, 38%, 30%, and 42% for colorectal, breast, non-small cell lung cancer, and renal cell carcinoma (RCC), respectively. In another part of this section, they state that compared with cancers with more than three to five metastases, “high-certainty evidence indicates OM tumors are associated with better prognosis in particular for CRC, breast, NSCLC and RCC”. However, was such a difference significant? In agreement with Reviewer 1, I would suggest to group studies according to histology, and to graphically depict the risk of oligometastatic vs. more advanced disease for each of the four tumors mentioned above.
- Figure 1: Please, clarify in the Methods section what “Records marked as ineligible by automation tools” means.
- Figure 2 and 3: Please, refer to my comments about the Results section.

Discussion:
- The Discussion was improved according to the suggestions of Reviewer 1, resulting in a stronger manuscript. There is an additional concept that I would address in the paper: the fact that the site of metastatic disease may affect patient prognosis, in addition to the number of metastatic lesions. In colorectal cancer, peritoneal metastases are associated with worse prognosis as compared with liver metastases, and lung metastases are associated with better prognosis. Furthermore, specific areas within the same organ may be related to a worse prognosis, e.g. a metastasis involving the hepatic hilum may be worse than a subcapsular liver metastasis.

Are the rationale for, and objectives of, the Systematic Review clearly stated?
Yes

Are sufficient details of the methods and analysis provided to allow replication by others?
Yes

**Is the statistical analysis and its interpretation appropriate?**
Yes

**Are the conclusions drawn adequately supported by the results presented in the review?**
Yes

**Competing Interests:** No competing interests were disclosed.

**Reviewer Expertise:** Peritoneal surface malignancies, advanced colorectal cancer

I confirm that I have read this submission and believe that I have an appropriate level of expertise to confirm that it is of an acceptable scientific standard, however I have significant reservations, as outlined above.

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Author Response 26 Sep 2021

Fausto Petrelli, asst bergamo ovest, Treviglio (BG), Italy

I have the comments of Reviewer 2:
- I changed the conclusion of the abstract as requested.
- I included a statement in the Methods section about the exclusion of non-English language papers and the NOS scale definition.
- I have modified Fig. 1.
- I have provided a new Fig. 5 with subgroup analysis according to disease histology.
- In the discussion section, I provided a brief discussion about the site of oligometastases (lung vs others), in particular for CRC.

**Competing Interests:** No competing interests were disclosed.

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Author Response 28 Oct 2021

Fausto Petrelli, asst bergamo ovest, Treviglio (BG), Italy

My responses to the comments of Reviewer 2:
- I changed the conclusion of the abstract as requested.
- I included a statement in the Methods section about the exclusion of non-English language papers and the NOS scale definition.
- I have modified Fig. 1.
- I have provided a new Fig. 5 with subgroup analysis according to disease histology.

- In the discussion section, I provided a brief discussion about the site of oligometastases (lung vs others), in particular for CRC.

**Competing Interests:** No competing interests were disclosed.

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**Version 1**

Reviewer Report 30 June 2021

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Luca G. Campana  
1 Department of Surgery, Colorectal and Peritoneal Oncology Centre, The Christie NHS Foundation Trust, Manchester, UK  
2 Department of Surgery, Manchester University NHS Foundation Trust, Manchester, UK

The authors of this systematic review and meta-analysis assessed the influence of oligometastatic disease status on OS and PFS in adult patients with solid tumours. To do this, they carried out an extensive literature review including all types of studies with at least ten patients with any histology. Patients with OM disease were found to have significantly longer PFS and OS if they had CRC, BC, NSCLC, RCC, and sarcoma.

The literature screening was conducted according to the standard recommendations and the subsequent analysis is methodologically robust. Going across several histotypes, the paper provides a big, and for certain aspects, unique picture of the prognosis of patients with OM. At the same time, however, it makes it challenging summarising and discussing the results.

Here you can find some comments that you may find useful to improve this review:

- In the Abstract, I would mention the histotypes in which the OM status do not correlate with patient outcome. Also, in the Conclusions part, second sentence: this seems to be unrelated to the results presented and anyway not applicable in all cases (consider rephrasing/changing).

- The Introduction needs some input because sentences do not always follow a clear pattern. For instance, there are some general considerations regarding tumour progression, tumour staging according to the TNM, detailed results of a specific trial. It needs to be more homogeneous.
Given the positive results with ablative therapies in patients with OM disease, the authors should explain what this meta-analysis adds to the literature.

From the Introduction (and Methods) it is not clear what the definition adopted of OM disease is ("up to 3 to 5" metastatic sites). In this regard, is a patient with 6 liver metastases still considered “oligometastatic”?

The great majority of the studies were retrospective in nature. This should be clearly stated and critically discussed as well.

Did the authors detect any imbalance in treatment intensity between OM vs. non-OM patients?

Table 1, 8th column: some of the included studies have "various" sites of OM. I think this information should be specified in order to be consistent with the inclusion criteria.

The studies could be regrouped according to the histology. The same could apply to Figure 2 and Figure 3.

The prognosis of patients with gastric cancer, melanoma, and head and neck cancer should be discussed in light of the results presented.

In the Discussion, it is not entirely clear if the authors consider the OM status an opportunity to spare patients from systemic treatment or an opportunity to pursue combined treatment. Again, this should be discussed in light of the results presented.

In the Discussion, the last paragraph seems more like a list of ongoing trials, including some form of local therapies over standard systemic treatment. How does this relate to the findings of the present study? Please discuss.

**Are the rationale for, and objectives of, the Systematic Review clearly stated?**
Partly

**Are sufficient details of the methods and analysis provided to allow replication by others?**
Yes

**Is the statistical analysis and its interpretation appropriate?**
Yes

**Are the conclusions drawn adequately supported by the results presented in the review?**
Partly

**Competing Interests:** No competing interests were disclosed.

**Reviewer Expertise:** Surgical oncology, locoregional therapies (limb perfusion/infusion, intraperitoneal chemotherapy, electrochemotherapy), melanoma, sarcoma, breast cancer,
I confirm that I have read this submission and believe that I have an appropriate level of expertise to confirm that it is of an acceptable scientific standard, however I have significant reservations, as outlined above.

Author Response 01 Jul 2021

Fausto Petrelli, asst bergamo ovest, Treviglio (BG), Italy

Reviewer 1: Luca Campana

The authors of this systematic review and meta-analysis assessed the influence of oligometastatic disease status on OS and PFS in adult patients with solid tumours. To do this, they carried out an extensive literature review including all types of studies with at least ten patients with any histology. Patients with OM disease were found to have significantly longer PFS and OS if they had CRC, BC, NSCLC, RCC, and sarcoma.

The literature screening was conducted according to the standard recommendations and the subsequent analysis is methodologically robust. Going across several histotypes, the paper provides a big, and for certain aspects, unique picture of the prognosis of patients with OM. At the same time, however, it makes it challenging summarising and discussing the results.

Here you can find some comments that you may find useful to improve this review:

- In the Abstract, I would mention the histotypes in which the OM status do not correlate with patient outcome. Also, in the Conclusions part, second sentence: this seems to be unrelated to the results presented and anyway not applicable in all cases (consider rephrasing/changing).
  - **Author response: OK - requests accepted.**

- The Introduction needs some input because sentences do not always follow a clear pattern. For instance, there are some general considerations regarding tumour progression, tumour staging according to the TNM, detailed results of a specific trial. It needs to be more homogeneous.
  - **Author response: OK - sentences added or modified.**

- Given the positive results with ablative therapies in patients with OM disease, the authors should explain what this meta-analysis adds to the literature.
  - **Author response: Sentences added in 2nd paragraph of discussion.**

- From the Introduction (and Methods) it is not clear what the definition adopted of OM disease is ("up to 3 to 5" metastatic sites). In this regard, is a patient with 6 liver metastases still considered "oligometastatic"?
  - **Author response: Definition updated.**

- The great majority of the studies were retrospective in nature. This should be clearly
stated and critically discussed as well.
  ○ **Author response:** Considerations added in the limitations section.

○ Did the authors detect any imbalance in treatment intensity between OM vs. non-OM patients?
  ○ **Author response:** This data was not reported.

○ Table 1, 8th column: some of the included studies have "various" sites of OM. I think this information should be specified in order to be consistent with the inclusion criteria.
  ○ **Author response:** “Various” means that in those articles, sites of metastases were not specific. Only when explicitly reported they are included (e.g. liver or lung). Specific comment in inclusion criteria added.

○ The studies could be regrouped according to the histology. The same could apply to Figure 2 and Figure 3.
  ○ **Author response:** Table and Figure 2 (OS) arranged according to disease.

○ The prognosis of patients with gastric cancer, melanoma, and head and neck cancer should be discussed in light of the results presented.
  ○ **Author response:** Sentences added in the Discussion.

○ In the Discussion, it is not entirely clear if the authors consider the OM status an opportunity to spare patients from systemic treatment or an opportunity to pursue combined treatment. Again, this should be discussed in light of the results presented.
  ○ **Author response:** In the final paragraph, some sentences were added about this request.

○ In the Discussion, the last paragraph seems more like a list of ongoing trials, including some form of local therapies over standard systemic treatment. How does this relate to the findings of the present study? Please discuss.
  ○ **Author response:** Discussion added.

**Competing Interests:** none

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Author Response 02 Jul 2021

**Fausto Petrelli,** asst bergamo ovest, Treviglio (BG), Italy

○ We have improved the Introduction and criteria for search.

○ We have arranged in the Discussion section a specific discussion about particular settings of patients analysed and the main limitation of the paper (retrospective nature of studies).

○ We also discussed the main meaning of the results: improved prognosis and
treatment opportunities with locoregional therapies in an oligometastatic setting.

- Table was also ordered according to histology.

**Competing Interests:** No competing interests were disclosed.